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SIXTY YEARS A BRICKMAKER.

A Practical Treatise

ON

BRICKMAKING AND BURNING

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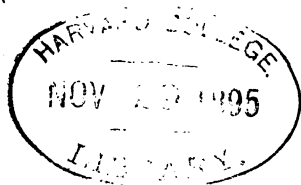
THE MANAGEMENT AND USE OF DIFFERENT KINDS OF CLAYS
AND KILNS FOR BURNING BRICK, WITH A SUPPLEMENT
FOR NEW BEGINNERS IN BRICKMAKING, AND
HINTS TO BRICKLAYERS AND BUILDERS.

BY J. W. CRARY, SR.

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1890.





BIOGRAPHICAL SKETCH OF THE AUTHOR OF THIS BOOK.

Mr. Crary is a native of Hamilton County, Ohio ; he was born in Springfield Township, a few miles north of Cincinnati, in the then sparsely settled village of Mount Pleasant, in the year 1814, on the 12th of November. Mr. Crary's grandfathers were from Vermont, and were soldiers in our war for Independence. They both came West in 1806. Mr. Crary's grandfather Crary settled near Cincinnati ; his grandfather Ballard, settled in Jennings County, Indiana. Both of these men were pioneers, and lived each to the advanced age of ninety-six years. Mr. Crary's own mother died in her eighty-seventh year. Mr. Crary's father established a brickyard in Cincinnati in 1829. Mr. Crary worked with his father until the late autumn of 1834, when he went South, and was, up to the close of our war of the States, a constant jobber, contractor, manufacturer, and superintendent as brickmaker, and part of the time as brick layer, just the same as his father had been from Mr. Crary's earliest boyhood. Mr. Crary patented a brick kiln and a brick machine, in 1858. Several features in these patents are now in general use. He also took out a patent for heating houses, by use of clay materials entirely, in the construction of his heater.

Mr. Crary operated his heater in the North successfully, until his health required his return to Florida. Mr. Crary also patented several important improvements. He is also the real inventor of the plan for cladding ships with iron, and has now in his possession, published evidence of the fact, that he suggested the cladding of the old U. S. War ship "Merrimac," which distinguished herself in the late war, in dispersing the U. S. fleet at "Hampton Roads," at the same time he was preparing to clad a small vessel, which was to carry a single gun, and make a breach in the walls of Fort Pickens. He had invented a peculiar shot, or arrow. It was a sharp pointed bomb with a light, hollow tail, so as to give it the projectile precision of an arrow. The main body of the shot contained a given charge of powder in a chamber. A priming tube, or nipple, connecting with the powder, was capped with a common percussion cap; a "striker" was set just behind in the hollow tail, the shot was then put in the cannon on a "sabbat," which covered the powder in the cannon. When this was discharged the shot went point foremost, and simultaneous with its penetration of a wall, it exploded and, of course, a breach in the wall was the result. Mr. Crary's versatility is remarkable; he is by no means a novice in political economy, and writes for public journals with acknowledged force and ability.

As Mr. Crary's writings show, some of his prominent work was making the brick by contract for the U. S. Arsenal at Little Rock, Arkansas, in 1840 and 1841; making and laying the brick for the State University of

Mississippi, in 1845, and 1846; superintending the making of all the No. 1 brick for the U. S. Custom House, in New Orleans, in 1852, '53 and '54; also, in superintending the making of the brick for U. S. Fort Jefferson, on Dry Tortugas Island, on coast of Florida, 1857, '58 and '59. He made all the brick for Iron Works at Red Mountain, in 1863 and '64, near Birmingham, Alabama. Mr. Crary is the projector of the village of Bluff Springs, Florida, and its main proprietor. As a citizen, a thinker and writer, Mr. Crary occupies a high and honorable position in the community, and has held some important offices, at the earnest request of his fellow citizens, without regard to party. He has always refused office, only when he believed it to be an imperative duty to accept.

PREFACE.

There are thousands of compilers, but few real authors of books. A compiler may select and arrange matter for a book and make it readable, but of no practicable value.

To prepare the matter based upon the practical experience, and in many particulars, the new and original thought of the author, is entirely a different thing. Whatever there is in this humble contribution of the author to the art of brickmaking, that may interest and profit the reader, it is the result of long study and patient effort of brain and hand.

In 1867, I determined to publish a short treatise on brickmaking, and went to New York City to select material to aid me in the work, but, to my astonishment, the largest and best libraries and book stores contained no book on brickmaking, and the little that I was able to glean, with the aid of expert clerks, from books of general information, was of such a perfunctory character, that I abandoned the effort to compile anything from the writing of others, and proceeded to publish a short treatise on the art of brickmaking, in pamphlet form, from my own experience.

Since that date the increase of cyclopedic literature has furnished much on the subject of brickmaking, from

which it would be comparatively easy to compile a book, but when done, it would be of no practical value to the craft.

The progress that has been made in the manufacture of brick and all kinds of clay goods in the past twenty-five years, renders much of what has been written by theorists, obsolete.

It has been the unfailing purpose of the author in the preparation of matter for this work, to deal with the practical questions that may arise in the art of brick-making. There are two classes of persons that make the chief improvements in the work and life of mankind. One is analytical, the other practical and philosophical. I belong to the latter class myself, if I may be allowed to classify myself. Much that I have learned has been the result of studying closely the action of matter and the laws relating thereto in my everyday experience, covering a period of fifty-eight years in brickmaking, in eleven states.

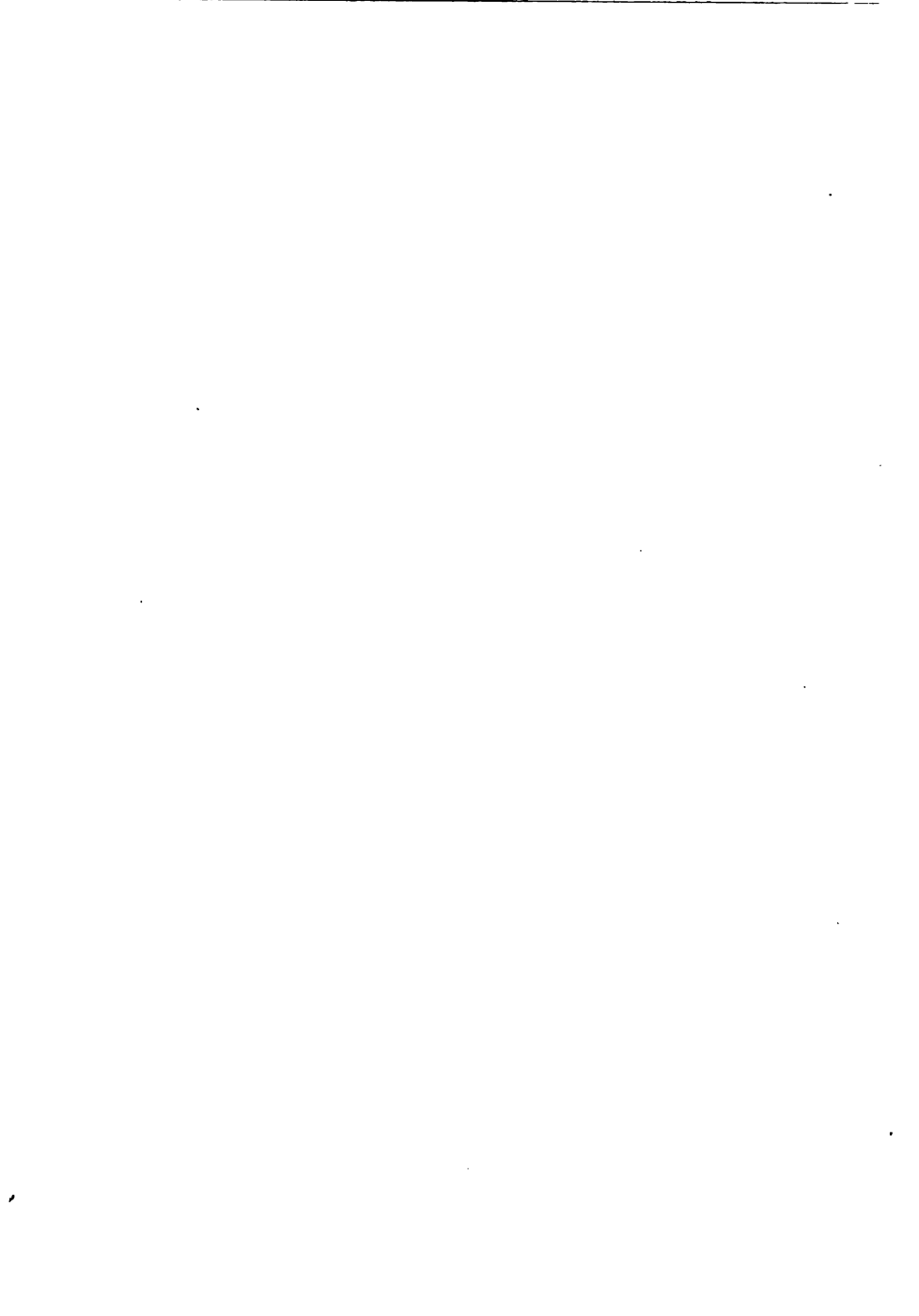
I venture to express the hope that this work will be helpful to those engaged in the art of brickmaking. Believing that in the management of clays, the drying, setting, and burning of brick, and in the construction of kilns, there will be much to interest even the most practical in the art.

In the supplement I have given directions to new beginners in the art of brickmaking, and hints to bricklayers and builders, which I hope will benefit and encourage amateurs in all lines of business pertaining to brick, so that they may achieve a victory over the forces

of nature, the varying characteristics of clays, the seasons, and other hindrances, and succeed in making an excellent brick and in doing the best kind of brick work at a minimum cost.

JOHN W. CRABY, SR.

Bluff Springs, Fla.



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BRICKMAKING AND BURNING.

CHAPTER I.

Clays for Making Brick.

It is needless for me to say that brickmaking is one of the oldest arts practiced by man, yet it has made less progress in its methods of operation than any other art. In this article I will notice the different kinds of clay that is, or may be, used in the manufacture of brick of all descriptions. (See Webster's definition of clay, which is right, except that he, like all brickmakers, says that clay will shrink or "contract by heat," which is only true as a rule.) All clays partake of a metal called aluminum.

"Fire clay," such as is generally used to make infusible brick for furnaces, is composed of alumina and siliceous, with more or less magnesia, and a trace of protoxide of iron, etc. In proportion as iron and alkaline salts are present in clay, in that proportion it is vitreous, or fusible; and in proportion to the absence of iron rust or sesquioxide of iron and alkaline salts, it is fusible. All "fire clay" has more or less alumina, siliceous and magnesia. The most of our primitive clays in the South, are infusible by ordinary heat of "the furnace." In some places I

have found that a kiln set 45 to 48 bricks high, would swell up three inches when perfectly burned instead of settling eight to ten inches, as in the case of fusible clays. The clay on my yard here, Bluff Springs, Florida, will perceptibly swell under intense heat; yet I can melt a brick made of it if I put two ounces of soda or potash with it before molding it.

The metallic oxides is what gives color to clay. Where iron rust, or sesqui or peroxides of iron predominate, we have that kind of clay that burns a bright cherry red. The alluvial clays of our rivers and creeks, and the ante-alluvial or diluvial clays of much of our "tableland," are of this character. The "silt" or clay deposited on the banks of the Mississippi River is alluvial clay, and makes a dull red, friable brick, easily burned, but fusible under a low heat. Most of the brick of commerce are made of the more primitive clays, or the ante-alluvial clays, such as are found on the plateau lands of our rivers. The red brick of Philadelphia, Baltimore, Cincinnati and St. Louis, for instance, are of this kind of clay. The largest, deepest and most unbroken continuous bed of this kind of clay in the United States, is to be found at Baton Rouge, Louisiana. It is over twenty miles long, and generally twenty-two feet deep. I have found this from personal observation, and have made some of the finest red front brick of it that I ever saw. In fact, this mammoth clay bed is nearly continuous on the east bank of the tablelands of the Mississippi river from Bayou Sara, Louisiana, to Memphis, Tennessee, about 400 miles long and an average of twenty miles wide.

FIRE CLAY.

Our fire clay beds are of two distinct kinds of deposit, one is in veins, or strata, conterminous with our coal fields; the other is the large homogeneous primitive clay beds of New Jersey, South Carolina, Georgia, Florida and Alabama. Nearly all of these clay beds are found near, or contiguous to the sea-coast. The largest, most extensive and best, are found in the southwest part of Florida, and southeast part of Alabama. The Perdido river is about the center, running north and south. The best developed beds of "fire clay" are found in Escambia County, Florida. In fact, the whole country is underlaid with one vast interminable bed of potters and fire clay, in strata from six to forty feet deep, often cropping out on the surface. This clay is suitable for all kinds of pottery, for "fire brick," and for the very best kinds of building brick, or blocks for street paving, and is cheap, accessible, and in every way advantageously situated for profitable manufacturing.

HOW TO TEST CLAY FOR MAKING BRICK.

I have known many who got the "brick fever," or "brick in the hat," to start, and with plenty of money, to get rich on a poor bed of clay. The first work I ever did was to "turn up brick" on my father's brick yard. I went to "off-bearing" as soon as I could carry three brick in a mold; then I was put at a "table" as soon as I was strong enough to mold, and I learned to mold in all ways, and all sorts of brick. I then was put to "setting," and

in due time, to "burning." We burned the old fashioned way, closing up one "head" or side, and firing from the other about three days, then opening the closed head and shutting up the open one, then sliding wood over with the old slavish "home pole" until the first head was 'settled,' then reversing fires and going for the "middles" and "last head." Now if you were an old scar-worn, weather-beaten "mud lark," that knew how to roast a stolen chicken, you would know just what I am talking about, and seeing that I have been sixty-five years in brickyards, you will say "he must be a brick," and not a "salmon" brick, at that.

When I started out for myself, I thought I knew all about brickmaking, and I got along first-rate while working along on the Mississippi River, where the clay was of the same kind I had been used to; I thought a brick-maker was a brickmaker, the world over. It happened that I left the Mississippi river, and went to Little Rock, Arkansas, in 1838. I had an engagement to make brick there, and I selected a clay bed which, in all appearances, was just the kind I had been used to. I soon had a kiln on fire, and the fires worked first-rate. I was very much pleased; but when I came to "settle the heads" just as I had always done, the irritation began. There never was a more sleepless, vigilant man at a kiln than myself. I had the fire blooming out all over the top; the arches were nearly to a white heat, and hotter than I ever had a kiln before.

I saw no signs of a "settle." I began to get scared; the idea that I had come there as a "crack, tip top"

brickmaker and now could not "settle" a brick kiln, when the fires and wood were all first-rate, was too crushing for good temper, so I got several cords of the best, dry, fine split, hickory wood, and burned it as fast as I could, and kept up a rapid combustion. The "arches" were so hot that I could not see the "overhangers;" they were as white as a snow bank. White blazes shot up all over the kiln, and the walls cracked so that the whole kiln looked at night like a mass of molten matter, not a particle of "settle" appeared, and I closed the kiln as the greatest phenomenon of my life. I knew the kiln was burned, but the quality of the brick was what concerned me. On the fifth day after closing I opened the kiln, and, to my most agreeable surprise, the perfect uniformity, ring, strength and color of the entire kiln, excepting the outside course of brick, was the most perfect I had ever seen. Then it was that I saw the wisdom of Dr. Franklin's aphorism, that "sensible people never finish their education." I saw that stereotyped practice in brickmaking would only do in the clay bed, where the practice was had, or one exactly similar, a thing only found on a continuous stratum in the same locality or kind of clay.

TESTING CLAYS FOR BRICKMAKING.

If a person desires to make brick, and has any concern as to the quality, he should first have some proper, practical knowledge of the business. Then if he goes into a clay bed which is unlike that he has worked, he should take a fair specimen of the clay and have it tested in some

BRICKMAKING AND BURNING.

brick kiln where brick are well burned. If no such kiln is convenient, take some of the clay and wet it, letting it soak over night, then divide the specimen, and temper one-half well, without adding any more water to it than was used to "soak" it, mold it in the form of a small brick; then temper the remaining half in the same way, adding water to it once or twice or three times, so that it will become much more plastic than the first half, then mold it likewise, and put both specimens in the sun to dry. If the clay has much lime or alkaline matter, the sample tempered and watered most, will crack in the sun and melt under a low heat, while the first specimen, tempered and watered only once, will not crack and will stand fire better than the other. Most people think that the more clay is tempered, the less it will crack in drying; but the reverse is true.

Clay is one of the most powerful hydrates known; it never parts with water until at nearly a fusible heat. Clay absorbs water in being tempered, until disintegration is complete, hence it may be watered from three to five times during the process of tempering, and its toughness and plasticity increased every time water is added. If clay be "loamy" and weak it may be made stronger by repeated wetting and tempering. The analysis of clays shown in books cannot be relied upon, unless made from a fair specimen to be used. I will, in my next, give a simple way to make an appropriate test of clay without burning it; but nothing but a proper, fair practical test will tell the truth about clays. Practice and science are so closely and necessarily allied in clay working, that none but "botches" will dispute it.

CHAPTER II.

Drying Brick. Testing Clay. Best Way to Prepare Clay for Plastic Mud Brick. Theory of Pressing Dry Clay to Perfection.

Near the conclusion of the first chapter in this book I stated the most practical way for testing clays in their nature of drying in the sun, for if clay will not stand sun drying, it will not, as a rule, stand sufficient heat in burning to make a good brick, though if clay cannot be had that will stand sun drying, still a very good brick may be made by tempering clay that cracks in the sun, in a "pug mill," and drying the brick on "pallets" under a shed, and if there be no shed or pallets the brick may be laid on a yard floor as usual in the sun, and as fast as laid down in rows, dust or sand may be sifted on the brick so as to cover the surface, thus forming a partial non-conductor of heat, so that a rapid contraction of the top surface of the brick is prevented, and the evaporation of water in the brick equalized on all sides; but in all cases, brick dried on a pallet under a shed properly constructed, is at least a third stronger and better than brick dried in a hot sun, especially if there be much wind. The slower and more equal on all sides a brick is dried, the less porous and stronger it is. If it is desired to test clay in burning

and no regular brick kiln is convenient, after a small sample brick shall have been made, as I stated in first chapter, such sample may be enveloped in a coat of clay, half an inch thick, and after being dried may be put in a blacksmith's forge with a very low heat until well dried off, then the heat may be increased until the clay coating begins to show signs of melting. Then let the fire die out and when cold take out the sample, knock off the coating, and though the specimen will not be as good as if burned in a kiln, yet it will determine the practicability of making brick of such clay.

THE BEST WAY TO PREPARE CLAY FOR "MUD BRICK."

Having decided on a "clay bed" for brick, if it is for mud brick, the clay should be dug and thrown up in the late fall, or through the winter, so that the rain and the frost will disintegrate and soften it as well as to dispose of an excess of salts or flux that may be in it. If clay be dug and hauled to the pit directly from the "bank," it is a difficult task to get it tempered so that the brick will be uniform in size or chemical composition, and if a kiln is not made of clay homogeneous in kind, quality and mixture, it is impossible to produce a good uniform size and color of brick.

The tempering of clay is a most important part in the manufacture of clay goods of any kind; nine-tenths of the brick manufactured are of imperfectly tempered clay. A perfect disintegration and amalgamation of clay is absolutely necessary to get the best results in the manufacture of anything made of it for building or do-

mestic purposes. The time is coming when the working of clay will be of as much importance and concern as the manipulation and mixture of iron and steel. Our "Lumbermen" seem to have a mania for destroying all of our timber forests. The ruthless and prodigal waste in the manufacture of lumber, and the excessive "output" thrown upon a glutted and sluggish market, will, ere long, exhaust the supply and clay and iron will be chiefly employed in building. The Arcade principle in architecture will be adopted, and clay will be molded in columns, segments of arches, and tiles, so that with a little iron the most massive structures as well as the laborer's cottage, will be built chiefly of indurated clay.

The streets of our cities will be paved with brick, or clay blocks, the size of two brick, but the clay must be strong and well tempered if molded, and thoroughly mixed and pulverized, if pressed dry, and in all cases perfectly burned. From these premises it is very obvious that the clay industry will, in all its departments, rank not less than third in mechanical pursuits.

TO PREPARE CLAY FOR "DRY PRESSED" BRICK.

In 1861, January 5th, I had a dry press brick machine of my own invention, described and illustrated in the "Scientific American," and I published a circular setting forth the whole theory of making and burning dry pressed brick. My machine gave brickmaking by dry pressure an impetus that has culminated in the fact that with the right kind of clay, handling and burning, the strongest kind of brick may be made by pressing

clay dry. If a substantial "plant" is to be made for the manufacture of "dry press brick" it is necessary to have a bed of considerable depth, homogeneous in character from top to bottom. Then the clay should be "caved," and then cut up well and hauled in under a large shed, which should be divided into two parts; one-half of the shed should be filled, say from four to eight feet deep, and with enough clay to run the machine three to six months. While that is being used up, the other half of the shed should be filled, so that a full supply of clay with its moisture equalized, can be constantly had. The raw material being thus prepared, a machine should be well put up that will pulverize the clay as fine as corn meal, and at the same time thoroughly comminute it before it goes into the press. The pressure should be applied slow. If it be a direct pressure press, there should be a top and bottom plunger, and only one of them act at the same instant, so that the present air in the clay may escape more perfectly. My machine exerted the pressure by a roller, which in passing slowly over the mold expelled the air before it. The clay should be dry enough to allow the brick at once to be set in the kiln. My machine carried the brick on a belt immediately into the kilns to the "setters," and the raw clay may be brought from the clay shed to the machine in the same manner, so that the whole process may be automatic, and all labor saved excepting the clay getting and the setting of the brick. If dry press machines do not do all this, the labor-saving feature is lost.

THEORY OF DRY PRESSING CLAY TO PERFECTION.

As I have said previously, clay is a powerful "hydrate." It absorbs water greedily and never parts with it unless subjected to a heat near fusibility. Clay in its different forms, conditions and admixtures with other substances, plays a more important part in the geological interest of the earth's surface, and its adaptability to the life and wants of man and animals than any other mineral.

A few of its actions are to absorb mineral poisons, and all poisonous fluids that come from the decomposition of vegetable and animal life. If it were not for the absorbing power and neutralizing effect of clay in solution, in the vast body of water in the Mississippi, and the clay deposits of the great "Delta," no animal life could exist on its shores. Clay in some form is absolutely essential and indispensable to agriculture, and so I might go on and enumerate *ad infinitum*. But to the point. It seems absurd to say we can make brick of dry dust—clay; but when we see that dry clay is a term that can only be used relatively, and that in fact, there can be no such thing as dry clay, we may hope to make brick by pressure, and I will give you the proof by a test you can make at any time, in two minutes, without costing a cent and you will be most astonished at its simplicity. Take a lump of clay as dry as you can get it, say two ounces, put it on an anvil or other smooth, solid, iron surface; then take a hammer with a smooth face, strike the clay a light blow,—you will crush it. Strike again,

you will reduce it to an impalpable powder. Increase the force of your blow a third or fourth time, and you find a thin, damp, lamelated piece of clay so dense, hard and strong that it resembles metal. The attraction of cohesion is thus perfected, so that if five or six pounds of the clay were put in a "Die," and fifty to a hundred tons pressure put upon it, you will have a perfect brick, and if burned properly, would be superior to any plastic clay brick. In a common size brick made by a good "dry press" machine, twelve ounces more clay is contained than in a "mud" brick of same clay and size. After a dry press brick is well made it is simply a question of burning as regards its superiority over a mud brick. Burning mud brick and burning dry pressed brick, are just as different as working and tempering steel for a common hoe, and the best blade for a sword, or spring for a watch.

CHAPTER III.

Difference in Burning Dry Pressed and Soft Tempered Clay Brick. Theory of Uniting Particles of Clay in a Body to Make a Brick, or for Other Purposes. Perfect Dry Pressed Brick Depends on Condition of Clay. Proper Way to Set Brick in Kiln for Burning.

I have said in chapter 2, that brick properly made of dry pressed clay are superior to those made of soft tempered clay. I stated how dry press brick should be made, and my statement was not based upon theory, but upon actual and successful experiment at different times and places, and in different clays. At one place I had charge of a dry press machine that made twenty thousand brick per day, also of tempered clay, molding by hand twenty thousand. I set and burned both kinds of brick in the same kiln, about half of each. I found that the dry pressed brick "dried off" slower than the mud brick, and the fire was slower in getting out at the top, but after "fires were up" the dry pressed brick burned out faster than the mud brick, and were ready to be "closed up" sooner, though "fired" the same way, but slower the first thirty-six hours. Those brick were made for the large United States Custom House in New Orleans, in 1850 and '51. The officer in charge came to our

yard to inspect the first kiln, which was very thoroughly burned, and though prejudiced against dry pressed brick, after a fair and full test, pronounced the dry pressed brick superior to the mud brick.

This brick yard was on Biloxi Bay, in the State of Mississippi. In 1856 to 1860, I had charge of a company's brick yard on Escambia Bay near Peninsula Florida. The concern was making brick for the U. S. Government, under a contract for sixty-five millions, to be used chiefly for the building of Fort Jefferson, "Dry Tortugas" in the Gulf of Mexico. The company at first, made brick altogether by hand—forty thousand per day was the "output." In 1858 we put up a dry press machine, which turned out an average of thirty-three thousand brick per day. Carrying the brick into kilns on belts and from them "tossed" to the "setters," at the same time, we made twenty-five thousand brick per day by hand. I set both kinds of brick in the same kilns. I set them five brick in a "bench" and from forty-eight to fifty brick high, our contract was for first quality, whole hard brick, and large high kilns turned out the best, we shipped ninety to ninety-five per cent of our brick to the U. S. Government. I found the same results in the burning, and character of the brick, as I had experienced before. The clay in both these cases would not melt or shrink in burning, even with fine, light wood fires, which, with a good draught, is as hot as any smelting furnace. The dry pressed brick were tested at Fort Jefferson, and carried fifty per cent. more pressure than the best mud brick of the best samples that could be found. I have made and

burned dry pressed brick, in seven different places. In two, the clay would neither fuse nor shrink in burning. In the other five places, one in New Jersey, one in New York, one in Maryland and two in Louisiana, the clay would fuse and "settle" in burning, from four to eight inches, and took twenty per cent. less wood or coal than the infusible clays.

THEORY OF UNITING PARTICLES OF CLAY IN A BODY.

A brick made of soft plastic clay, contains about twenty to twenty-five per cent. of water in weight. If the clay be strong or pure and thoroughly tempered, it will absorb about thirty per cent. of its weight in water when tempered soft enough for easy hand molding. It is evident then, that the particles of clay which are infinitesimally small, are surrounded by water to a certain extent, so that when a soft brick begins to get dry, a partial process of crystallization of the clay begins on the surface, and as evaporation goes on, the crystallization, or cohesive attraction increases, until the brick is hard enough to handle, or nominally dry, though theoretically damp.

If we take such a brick and break it, and examine it, we find the particles of clay cohered in sharp edged crystals, but pointed at their angles, so as to allow the water to escape, and leave one compact body but full of pores. We call this a solid, dry brick.

Now if we take a brick of this kind, and put it in a die, and apply one or two tons pressure, it is crushed, if the pressure be increased to ten tons, the particles of clay

begin to assume their natural position of cohesion, and as the pressure is increased, cohesion follows in the same ratio, until it becomes perfect, and the brick that a moment before was crushed to a disjointed mass of broken crystals, has now become one perfectly dense, solid body, without a single pore, unless made by confined air. A perfect dry pressed brick, well burned, will absorb but very little more water than a stone, and is about sixteen percent. heavier than a mud brick of the same size.

THE MAKING OF A PERFECT DRY PRESSED BRICK DEPENDS ON THE CONDITION OF THE CLAY.

We hear of semi-dry pressed brick. The well informed brickmaker, would call that by its right name, which is "stiff mud," and poorly tempered, because it is impossible to make clay plastic, or compel it to cohere, like well tempered soft clay, by any process of disintegration or co mixing. "Semi-dry clay," as very damp clay is called, cannot crystallize, it is not sufficiently wet, comminuted and plastic. It cannot be perfectly cohered by pressure, because the presence of a considerable amount of water intervening between the particles of clay, prevent perfect cohesion.

The natural dryness of clay is the right condition.

If clay be spread out in the hot sun, until it appears perfectly dry, it still retains a certain amount of water, and if perfectly pulverized, may be pressed into a solid body, but the moisture is not properly equalized until sun-dried clay has been at least a week, packed under a shed; then it becomes pulverulent, and easily yields

to the action of machinery properly constructed, and a comparatively solid body is made, much more tenacious, hard and strong, and less liable to warp or fuse by heat, than if molded of tempered plastic clay. I know of a clay working manufactory in a large northern city, that tried every possible way, at great expense, to make floor tile to compete with the celebrated "Menton" English tile, out of tempered moldable clay, but failed in every experiment. At length, finding they could not get the secret from the English manufacturers, they were about to abandon the effort to accomplish the enterprise. Just then, they accidentally got one of my circulars, which I had published, to show the theory upon which my dry press brick machine worked, which I had put in operation at Baltimore. Then they pulverized their clay thoroughly, and by means of proper dies and pressure, succeeded in making a first rate floor tile; every one was true, straight, and of uniform size, and hard as steel. I did not know how "Menton" tile were made, until long after I had conceived of, and practiced the same theory.

Dry pressed clay will stand fire much better than tempered clay. In the kilns where I have set and burned both mud and dry pressed brick, I found the "overhangers" on the "arches," of the dry pressed brick, perfectly sound and solid, while those of the mud, or semi-mud brick, were cracked and easily broken. I have used dry pressed "overhangers" over and over, ten times, for "overhangers" in the mud brick part of the kilns.

The reason for this difference is, that a dry pressed brick, being more dense than a mud brick, does not heat

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so fast, or cool off so fast. What constitutes a good "fire brick," is its ability to stand sudden temperatures of heat and atmospheric changes, without fracture, as well as to stand intense heat.

THE PROPER WAY TO SET BRICK IN A KILN FOR BURNING.

I will not in this chapter, express my opinion as respects the best kind of kilns for brick burning. There are so many different kilns and ideas connected with this business, that it is not easy to make a choice. The main thing involved in the question of kilns is economy in labor and fuel; "quality" is not a factor of any importance in the construction of a brick kiln. A perfect brick can be burned in an old-fashioned "cased up" kiln. The great art and secret is in the setting and burning. No kind of a kiln will turn out a perfect brick without these capabilities and conditions. We had just as well try to make a forge, that would temper steel without the hand and eye of an expert.

Brick should be set in a kiln, so as to get the best draught, and combustion of fuel, leave the least fire marks on the brick, and get the best distribution and equalization of heat.

To do all this now, I will take, for instance, an old style kiln to build. I will build the side walls twenty-five feet apart inside, they shall be at least three feet thick at the bottom, and tapered on outside to 18 inches on top. If the clay stands fire well, I will build the furnaces so as to allow a "bench" for "overhangings," five

brick wide ; if the clay fuses easy, will make the benches four brick wide. Having my kiln ready for "setting," I will set my brick zigzag, or "skintling," so that if two brick are set on edge, one-half inch apart, one brick set on two would cross them diagonally, so as to rest on the outer corners of the lower brick, the divergence of parallels, of upper and lower course, would be, as a rule, one-half the thickness of the brick. I will set this bench five brick high, and set them to average half an inch apart. I will then start my "overhangers" and set them the same as the benches. The first binder over the closing of the "overhangers" I will set close, so as to spread the fire ; all other binders I will set loose. Now I will put on the cross, "running course," loose, then I will start over these "cross courses" and if I want solid, even colors on the edges of the brick, I will set two courses one way, brick over brick all the time, before I cross them, thus preventing "fire marks," except when the courses are reversed. I will thus proceed to top of kiln, then "plat" with burned salmon brick, if on hand if not, will use dry unburned brick. The "platting" should be laid flat, and about one inch apart, so as to leave a good draft and escape for watersmoke.

CHAPTER IV.

Importance of Thorough Good Burning. True Theory of Burning Clay to Perfection. How to Make an Even Settle All Over Kiln. The Settle of a Kiln No Sure Sign of a Good Burn.

In third chapter I gave the common old mode of setting and burning brick. As some persons who are inexperienced may profit by a partial repetition of the same, I will state that when a kiln is ready to "fire," the main thing to consider is a "good burn," not a quick burn or a fuel saving burn. It is a foolish boast of the botch burner to talk about his quick burn. This is so common that it is quite the rule to make a bad burn just to brag about the time and fuel saved. Look a moment at the utter nonsense and certain loss of this costly practice of ignorance and self-conceit.

You have been to all the expense of making and setting ready for burning, say 200,000 brick. Now as a common old rule, it will take at least sixty cords of the best kind of wood, or about thirty tons of coal, to burn this kiln, or its equivalent in gas or any other fuel, and this is supposing that the kiln is in first-rate order for burning, that the clay is easy to burn salmon, *i. e.*, will indurate under a low heat, that the weather is favorable and that the help is ample.

Now suppose when the 60 cords of wood or the 30 tons of coal are used up on the fourth or fifth day of burning, the kiln be closed with 50,000 salmon brick and 10,000 pale red brick. Now the difference between this and a good burn is at least 40,000 salmon and 8,000 pale red. Loss by 40,000 salmon, \$80 at least; on 8,000 pale red, \$20, equals \$100 loss in selling price besides loss of labor in handling, \$10, equals \$110.

Now suppose the "boss burner" to be competent and that he tells his employer that he can make a first rate burn if he has five more cords of wood, or its equivalent in the fuel he may be using, and 10 or 12 hours more time. The cost would be say \$15 for fuel and \$5 for labor, equals \$20; but "no," is the answer and the kiln is closed up at a loss of \$90 together with the bad name "poor burn," "poor brick," or "salmon burn." So here is the actual damage of \$90 and an unknown incidental loss in reputation.

I have known hundreds of kilns to be treated in this way. In fact, first-rate brick burning is the exception, not the rule. I have burned a kiln of reset salmon brick in thirty-six hours, and several kilns of dry, green brick, in three days and nights, and although they were called good burns I found that in the same clay I could make a brick 50 per cent stronger by burning six or seven days and with a trifle difference in cost.

TRUE THEORY OF BURNING CLAY TO PERFECTION.

Six pounds of strong clay when dry as the air will make it, still contains from five to six ounces of water,

and brick set up in a kiln will average ten ounces of water to each brick. The pores of a mud brick are very small and of a dry pressed brick still smaller. Now it is perfectly plain and evident, that when a brick is heated above the boiling point, an instantaneous expansion takes place in the absorbed water and the crystallization or cohesive attraction of the particles of clay must be disjoined to a certain extent, so as to allow the excess of steam to escape. The whole body of the brick is thus suddenly expanded and softened, and if not perceptibly "water settled," it is, in fact so, to a certain extent, and however hard the brick may be burned it will be imperceptibly fractured, and lose its ring and solidity.

IN THE DRYING OFF PROCESS,

Brick should never be heated above the boiling point until the top of a kiln is quite warm to the touch all over. After this, the fires in the arches may be slightly increased, so that the overhangers will look a little bright after dark, but in no case should the furnaces or arches be made red hot, until the steam or water smoke begins to disappear rapidly. There are two words for a brick burner to get by heart, and never forget, viz., slow, and regular. If the aphorism "more haste than good speed" has one place better than another it is in the practice of the average brick burner, trying to save time by pushing his fires or opening his kiln too soon after being burned. No matter how little or big the kiln, if the height be the same, it requires the same length of time to burn it. I have burned 700,000 brick in a kiln 48 brick, ←

on edge, high, in a little less than seven days. The kiln did not settle a particle, was perfectly hard from bottom to top; and I have been a full week burning 100,000 the same way in the same kind of clay.

If the settle of a kiln be the criterion for a good burn, the slow, steady heat well diffused throughout the kiln is the only sure way. A settle should never be attempted until the fires are all out to a glowing heat on top. The man who settles his kiln until in this condition, is either a willful botch, or a senseless ignoramus.

HOW TO MAKE AN EVEN SETTLE ALL OVER THE KILN.

The old way of setting one head or side at a time is an exploded idea with brainy brick burners. A clamp or kiln, twenty-two feet wide should have a furnace at least four feet deep, or out, from the brick in the kiln. If the wall of clamp or kiln is not that thick, a flue or furnace should be built out so that the main part of the gases generated by the furnaces will not be mixed with fuel (wood or coal) thrown over into the arches. The old idea of sliding or throwing large quantities of fuel over to the center of a kiln is a positive waste of fuel, without any really beneficial result. If there be a deficiency of oxygen to consume the wood or coal thrown over to the middle of arches, the fuel will carbonize and that will retard or even destroy combustion. If coal be used the grates should be thinly covered, and the ashpits should be often cleaned out. When any part of the kiln begins to settle, the platings should be closed tight at that part, so that no more draft will concentrate at that point but be

forced to other unsettled part of the kilns. This process of closing the platting should go on until the settle is even all over the kiln, and if the platting cannot be made tight, raw, damp clay should be thrown on, so as to compel the draft of heat to go to the unsettled places. By this means, I have settled a head clear out nearly level with the middle.

WHEN THE KILN IS TO BE CLOSED AND HOW.

If the clay will fairly settle six inches, as soon as it has gone down four, you may safely believe it will settle two inches more, because the top of the kiln being closed, the intense heat below, will naturally ascend, and as it can only radiate from the top, of course, the heat will be very nearly equalized throughout the kiln, and the second course from the top will be good hard brick. When the kiln is to be closed, no fresh fuel should be added to the furnaces, and the gases having been consumed, so that no smoke is visible, should be spent until the arches have an even glow of a settling heat, then quickly close the doors and shut off the draft as soon as it is safe for the grates, which will not exceed one hour. The usual way of charging the arches with fuel on closing up a kiln is sure to discolor many of the brick, because the combustion, or rather, the consumption of the fuel, for the want of oxygen, is incomplete, and the carbonic oxide discolors the mineral oxide which gives the natural color to brick.

We see and hear a good deal about burning brick with natural gas. This is an important subject in locali-

ties where gas can be had, but in most places we must generate the gas by the proper combination of some kind of fuel and oxygen. Brick burning is not a question of fuel or heat, but a question of the right and best application of heat, and cooling or withdrawing of heat. It takes a certain quantity of heat, or caloric, to produce that chemical change in clay necessary to oxidate its natural constituent parts to that state of induration which affords the most consistent hardness, strength, tenacity and durability.

THE SETTLE OF A KILN NO SURE SIGN OF A GOOD
BURN.

That kind of clay which is generally used to make the best red brick, will shrink about an eighth of an inch in the width of a brick; that will give five inches settle in a kiln forty brick high. But we often find such a kiln settled 8 to 10 inches or more and the arch brick a half inch less in width than a brick in the middle of the kiln, and the difference in settle from the bottom to top, is in ratio to the number of courses. This may be called good burning, but it is because there is no better. Why not have the superlative and get the best? It is simply a question of time, distribution and equalization of heat. Any experienced brickmaker, of first-rate judgment and sense, (and no other sort of a man ever was or ever will be a first-rate brickmaker,) will soon find just how much heat his arches will stand without signs of fusion. Then if the brick are properly set so that a free, clear draft can ascend, he has only to keep the heat steady, uniform and

regular, until the same color or glow of heat can be seen down a course or two from the top as is seen in the arches, and when this sign is plain and unmistakable, he may close the kiln without regard to the depth of settle, and uniform well burned brick is the certain result. Any other criterion for a good burn is deceptive. The settle of a kiln may be mostly in the arches, while two-thirds of the brick above, are only pale red, and salmon.

In my next chapter I will say something about our infusible clays that don't shrink in burning, and require intense heat, and will also tell common brick burners in fusible clay, how they can make their arches stand fire. Further on I will show how to utilize the heat of kiln, after being closed to dry off other kilns which can be set up at little expense for continuous burning. I will say right here, to finish my remarks about setting arch bricks, that the common way of setting benches and overhangers, by setting one brick on two, right over the space between the two, is without reason or common sense, as it only makes cavities or ovens, which confine the heat and gases, not allowing escape up into the body of the kiln. The benches, overhangers and binders should be set skintling (reversed diagonally) with a space between at least 5-8ths of an inch. There should be a free full escape for draft up from bottom to top of kiln. "Benches" may be four brick wide for clay easy to melt and five brick wide for clay that will stand a high heat.

CHAPTER V.

*Certain Growths of Timber Indicate Certain Kinds of Clay.
Burning Brick with Coal Dust, or Other Fuel Mixed with Clay.
Burning Plastic Clay Brick and Dry Pressed Brick. Burning
Dry Pressed Brick Direct from Machine.*

In my former chapters I have given some general directions about selecting clays for brick, and for preparing them and making and burning them into brick. Most writers (not excusing myself) are egotistical, vain and self conceited, and the *we* and *tear* of pronouns of the first person singular, is dreadful. Still "I," "me," "myself" at the right time and in the proper place, makes a better show for true energetic and forcible manliness, than "he," "we," "they," "it," with a vain pride for fastidious modesty. You always know where to find "I," but "he," "we," "it" and "they," are sometimes awful dodgers.

I will now state a fact which I defy any experienced clay hunter and worker to deny, and as I cannot very intelligently explain it myself, I will call on some professor, who can give you all you want to know about brick, (whether he ever saw a kiln made and burned or not) to solve this question. I have never seen a clay bed East,

West, North or South, upon which a variety of timber grows but what will make good brick. It will not crack in drying or check in burning; and generally, will burn red color. I have never seen a clay bed where there is, or was, no other timber than oak or pine, but what would crack in the sun when molded soft, and easily check in burning. Will some facile, juvenile, versatile writer, tell me why?

When I speak of clay on the surface, where any timber grows of course, no reference is made to antediluvial or primitive clay, or what is commonly called fire clay, or potters clay, nor do I refer to alluvial clays, such as are found on the low banks of the Mississippi, and other rivers, but such as are found on the plateaus or table lands of our rivers and valleys. Most of these lands have a variety of timber on them.

Oak and pine clay lands, have generally, a large proportion of calcareous matter. Traces of fossil shell fish, may be seen in the pine or oak clay lands of the South, especially in Alabama, or Mississippi. These clays dry fast when molded soft, and shrink more than other varieties, and being poor in silica and rich in lime, the particles have not time to arrange themselves into a solid crystal, while the water is evaporating.

As a proof of this theory, if we add sand, say one-fourth or less, as the case may be, we find no cracking; if we dry the brick under sheds, we have good, strong, whole brick; if we press the clay dry, when well pulverized, we find no cracks, but a good, strong brick, if properly burned. This kind of clay, should have as much

sharp, clean sand added to it as it will bear and make a good brick, unless it be manufactured by a first-rate dry press machine.

BURNING BRICK WITH COAL DUST OR OTHER FUEL
MIXED WITH CLAY.

A few years ago, (and I presume the practice is continued) nearly all the brick made on the Hudson River, N. Y., and Raritan Bay, N. J., were made of tempered soft clay, and from three pecks, to one and two bushels of fine coal dust was tempered in with each thousand brick. The brick to be set around on the outside, and "heads" of kilns, had double the quantity of dust. When a kiln was ready to fire, wood was used sparingly, and when the arches became hot enough to ignite the coal in the brick, very little wood was used, and the doors were kept closed, with just enough air admitted to keep up combustion. The heat would follow close after the water-smoke and the top of the kiln would be harder than the bottom.

A CHEAP BUT BAD WAY OF BURNING BRICK.

The brick burned with coal dust tempered in with the mud or of clay containing lignite, (as is used extensively in Middlesex County, Raritan Bay, N. J.) are of an inferior grade. First, the water-smoke is driven off too rapidly, warping, checking or water-settling the brick. Second, the inside of the brick becomes fused, while the outside is partly chilled, and remains comparatively soft. Third, the brick are discolored, and have a motley ap-

pearance and the grain or texture of the brick, being uneven and entirely dissimilar, it is liable to chemical and atmospheric action.

The difference between the intrinsic value of a thoroughly and evenly burned brick, and one that is half fused and half burned, cannot be compensated by any kind of economy in fuel or burning.

When all architects, and builders, get to know a brick, the man who can burn a thousand brick with three pecks of coal, and a wheelbarrow load of wood or 25 cents worth of gas, will be out of a job, and good brick burning will take high rank as a profession.

I have not a doubt that the time will come after our natural fuels have been much or nearly exhausted, when heat for burning brick, and for many purposes not now thought of, will be developed from water power and electricity.

I have said in preceding chapters, that clay that will crack in sun-drying should be tempered in a pug mill, water being added to it only one time; and that clay which is loamy, or charged with sand, so as to make it short or weak, should be tempered in a pit, and worked until it is stiff, then watered; this process of tempering and watering should be continued, until the clay particles become so disintegrated, that the whole body feels plastic to the touch. Millions of good, fair building brick, are made on the river bank at New Orleans, Louisiana, in this way, of the deposit of sandy mud or *batture*. It is taken out when the river is low, and kept in store, for spring and summer use, and the next succeed.

ing high water replaces the mud taken out, so that the excavation is not seen. Thus the great "Father of Waters," carries on his work of alluvion, which has furnished mud for brick, and millions of fertile acres for agriculture.

BURNING PLASTIC CLAY BRICK AND DRY PRESSED CLAY BRICK.

I have already given some directions for burning and setting brick. In the preceding chapters I stated that there was a material difference between the right way of burning the two kinds of brick above mentioned. A mud brick having much more water to evaporate than a dry pressed brick, when dried off, will, of course, be more porous than a dry pressed brick, and will absorb heat more rapidly. If, therefore, the two kinds of brick are set in one kiln separately, it will be found that the mud brick will be dried off and the fires up, sooner than the dry pressed brick. It is, therefore, evident that the dry pressed brick should be fired slow, steady and carefully, for if fired to keep up with the mud brick, they will expand or swell so as to partially lose the cohesive attraction the particles of clay have assumed under pressure. This is of the first importance, for if the cohesiveness of the particles of clay be once disturbed, nothing can restore it.

BURNING DRY PRESSED BRICK DIRECT FROM MACHINE.

If your clay has been dug and hauled when dry, as it naturally gets in the bed, and stored under a good shed, it

will be in good condition to press after three or four weeks under shed. It will get but very little dryer under a shed than it was in the bank, but it will be uniform in dampness and mulled, ready for the pulverizer.

Clay in this condition, will be dry enough to go at once into the kiln from the machine. Brick can be well burned if dry enough to stand in a kiln without crushing, provided they are evenly well set and the firing very slow and careful. If the clay be frozen when pulverized, in a so-called dry state, it may be pressed and set directly into the kiln, but if pressed damp without being frozen, and then frozen, it will not be a brick when thawed, but a crumbling body of clay, unless kept frozen and exposed to the air a long time. Dry pressed brick should be set even and open. A good and safe rule is to set five on edge, on the distance or length of two, or say three-quarters of an inch apart. As I have said in previous chapters, the benches and overhangers, should be set skintling or diagonally across, one on two, in form of letter X. This should continue until the binders are on and ready for first running, or lengthwise course across the kiln. For common brick, I prefer to set skintling all the way to the top. If set even this way the circulating draft and flame is more regular and diffusive. It requires more skill to set skintling, but a setter can set much faster. When a kiln is set skintling, the course of draft up through the kiln is serpentine, and the circulation of heat is more lateral, and better distributed than when the brick are set transversely, three over three. The benches of a dry pressed kiln may be a brick wider than

for mud brick, as the clay, dry pressed, will stand more fire. Five courses wide will do well with good burning. Forty brick high is a good maximum for setting a kiln. The width may vary, but I prefer a narrow kiln not over 24 feet wide. The fires can be worked and controlled well in this width of kiln.

I have spoken of fusible and infusible clays, and have shown that the infusible clays will not shrink or settle by burning, and that the fusible clays will stand fire better by being dry pressed. When a dry pressed kiln is ready to fire, if with wood, the greenest, or if all dry, that which has the least resinous matter, should be used first, for if much black smoke passes up through the kiln when cold, it will coat the brick in spots. This not only chokes the draft, but is a non-conductor of heat, and what is called a chill or cold spot is likely to ensue. This is not infrequent, with ignorant burners; some call it "witch in the kiln." I have seen them dig to the arches to get it out, but the best way to get the "witch" out is to pour water enough down from the top, to start hot steam from the hot arch, then it will follow up by pressure of steam. But this "witch," must be prevented by a very slow and clean fire. If coal be used, hard coal is best for drying off; bituminous coal is best after the kiln is hot. When the fires are all out at top, the heat should be increased until the overhangers show signs of fusion or glazing; then this heat should be kept steady, until it appears on top. In clays that don't melt by heat or settle, the platting will first show a white sulphuret of any alkaline matter in the clay. Then as the intense heat ap-

pears under the platting, a sulphuret of iron, or what burners call "brown sulphur," will coat the edges of the platting. This is a sure sign of hard brick from bottom to top, as all the mineral substances of the clay have become completely oxidized. This efflorescent appearance of oxidized substances in clays, is the true indication of the quality of a burn, and not the settle, as common brick burners believe. If clay melts at a low heat, as soon as the arches get red hot, the danger of fusing may be very much prevented by closing the kiln up tight, for five or ten hours. I have closed a kiln at 9 p. m. and opened it 6 a. m. and found it in good order, and very hard to melt afterwards.

Reason: The alkaline salts have been greatly dissipated and ceased to be a ready flux with the clay under a high heat. Thus closing a kiln to let it "cook," is not only good to prevent fusing, but it is the only true and sure way to get out a cold spot or "witch." After closing a kiln tight for eight or ten hours, when re-opened, the draft will be very strong and so equalized, that all cold spots will disappear.

CHAPTER VI.

A Notable Experience. Hard, Well Burned Brick, Only, Used On U. S. Public Works. How to Toughen or Anneal Brick While Burning.

If the readers will look carefully over the preceding chapters of this book they will get enough information to enable them to form a very correct idea of clays, brick-making, setting and burning. They give a very general description and theory of the art, and if any intelligent man of good practical judgment, with an inventive, inquiring mind, and an energetic, patient industry and perseverance, will follow the suggestions and directions given, he will be able to judge and decide, all the main questions preparatory to the establishment of brickmaking.

After all the preliminaries have been decided upon, the next important thing, is to get the services of the very best and most skillful, practical brickmaker. Right here, I will indulge in a little episode of my own life, but the reader will justify my egotism for the value of the lesson. In 1855, a wealthy company here in Florida, undertook to make 65,000,000 of brick for the different U. S. fortifications on the coast of Florida. Not one of

this company had any practical knowledge of brickmaking, but they had plenty of money, slaves and credit. They were, however, as cautious and capable as most men of the country, and secured advice and services of the best native brickmaker they could get. He told them of suitable locations, they paid \$10,000 for one, and employed this brickmaker to superintend the practical part of the business. He had made and burned brick before on the same place, and they thought they had a "sure thing," but there was a "Lion in the Path."

The United States contracted for "best whole hard brick," and there was an officer on the U. S. Works that knew a brick when he saw it. The company dashed ahead and soon had a kiln burned, and although a good kiln for building purposes, not ten per cent. of it would bear government inspection. The company had to go into the brick market, and pay a high price for brick to supply their contract; but they had pluck and determined to succeed making the brick. They worked two years, spent \$75,000 and did not make 50,000 brick acceptable to the government. Then they abandoned the place, bought another at the cost of \$10,000 in the same locality, employed the same brickmaker, and again failed to make to make and burn brick to suit the contract. The company employed other brick burners, the best they could find, with very little better success. They became discouraged, and were about to pocket their loss and quit, when accidentally they were told that I, then living in New Orleans, made a specialty of burning brick for United States work, and if they could get my services

at any price, they would do well. Now, to make a long story short, I took charge of this company's establishment in 1857. 16,000,000 of brick, about 95 per cent. of all we made, went to the government before the war commenced. I got my own price for my services and had my own way. The company recovered their losses and made money.

As I have said previously, the art of clay working is the oldest, and has fewer real experts than any other, save what we call "fine arts" and it is no disparagement to these, to say, that a perfect clayworker is an artist of no mean order.

On all three notable occasions, at different times and places, I have made first-class brick in large quantities for the U. S. government, when all efforts of others, who had the same or greater facilities, utterly failed to compete. I cannot tell any man just how he can perfectly burn a kiln of brick, no more than an expert painter can tell another painter, just how to naturalize, or imitate the object he desires to paint. I rarely manipulate the burning of kilns alike. Weather, fuel, clay, conditions; all these things, are to be noted and considered. The man who burns brick in a given time, with a given quantity of fuel, never was, and never will be, a first-class burner. He must fire his kiln right, and fire until it is thoroughly burned. He must have varied and repeated practice, and with all, and above all, a keen analytical and discriminating judgment.

HOW TO TOUGHEN OR ANNEAL BRICK WHILE BURNING.

In previous chapters, I have said that the art of burning brick, or anything of clay, is very much like that of working and tempering metals. If, for instance, it is desired to make cast iron very hard and brittle, it is cast in a cold iron mold, or chill, so that it will cool quick. If it is to be made soft and tough, it is cast in sand, and the air kept from it as much as possible, until it becomes cool. So in like manner, clay may be made very brittle, or it may be made hard and tough, so that it will stand great pressure, or may be cut to a sharp edge or angle, without flaws or fracture. I have annealed brick made of strong clay, silicate of alumina, so that a brick 9 by 4½ by 2½ inches, carried on the flat, the enormous weight or pressure of 250,000 pounds without crushing. Out of twenty samples of brick from different parts of the country, North and South, only five brick stood 180,000 pounds.

TO ANNEAL A KILN OF BRICK.

The water-smoke should be carried off slow and steady, then the heat should be gradually increased, until the overhangers are as hot as they will stand without drooping. This heat should be kept steady until it can be seen all over the kiln, then the spots on top of the kiln showing the same heat of the arches, and the edges of the platting showing a dark or copper-colored sulphuret, should be closed tight with fine clay, and as fast as these spots appear, cover them over

tight until the whole kiln be covered, except the margins, say eight inches from heads, and outsides. The kiln is now perfectly burned and should be closed tight and kept so, until a brick can be taken out from the top without burning the fingers. Then the arches may be opened, and a good strong brick, with uniform hardness and color throughout the kiln, is the certain result, excepting the outside course and one course on top the kiln. The idea of trying to work the fires in the arches so as to burn out slack, or cold places on top, is folly, and a loss of time and fuel, as well as a damaging exposure of the brick to the air, when the fires are unequal in the arches. From the time the arches are at the maximum heat, until the kiln be closed, our arch should be kept at the same uniform heat. There is no possible way to work the fire out on the top, with uniform certainty only by covering as before stated. As the kiln is covered, the draft is forced to the uncovered parts, and the combustion of fuel, when the kiln is covered, is not retarded and very little fuel will keep the arches as hot as they will heat, and the danger to melt is at the same time diminished and the heat throughout the kiln is equalized. I got a patent for this process in 1856, together with other features, and I have never failed at any time, or place, or in any kind of clay, or with any kind of fuel, to make a perfect burn. Platting may be closed on burnt out places, but it is not as good as fine clay to work the fire, and clay don't hurt the color of brick, if shoveled off clean with platting, which should be brick bats. I prefer to "plat" with one course of bats, then as the sulphur

shows up on edges of platting, and a place begins to "settle," (if the clay will settle,) I cover the spot with fine damp clay, about three-quarters of an inch thick, so as to stop the draft of heat from that place; this prevents an excess of heat at that point, and saves it for a colder place, and so the process of covering goes on, until the whole kiln is covered.

The best way to "*damper*" or cover a kiln, is to have a small scaffold near the top of the kiln; put up a ladder, and two hands will carry clay up in buckets or sacks, as fast as an expert will put it on the places to be covered.

He will not suffer from the heat or even burn his shoes if he will just drop a little clay, where it is very hot to step on. When he "dumps" his clay on a place to be covered he should spread it with his foot, treading it a little to make it tight.

When the kiln gets cold and ready to open, let a careful hand take a good, straight-edged shovel, and run it under the bats and clay, and throw it off; little or no dirt will fall down into the kiln. It takes no extra labor to "*damper*" kiln on top, and it makes a perfectly burned, strong brick.

CHAPTER VII.

Theory of Drying Clay to Prevent Cracking. The Reason Why There are So Few Scientific Brick Burners. Superiority of Good Brick Buildings Over all Other Kinds. How to Build a Cheap and Most Excellent Dwelling House.

In my last chapter, No. 6, I showed the difference between burning soft tempered clay brick and brick made of comparatively dry pulverized clay, under heavy pressure. As there are many who do not understand why all kinds of clay may be pressed into a brick without cracking, when it is dry and well pulverized, while perhaps the same clay will crack by hot sun drying, or in a dryer, I will repeat what I have before said, that all clays of a marley or limy character, will crack in drying, unless dried very slow. But such clay could be dried on dryers if put on pallets, and the dryer closed steam tight, and then kept full of steam until the brick would be heated clear through; then the steam turned off and hot air, about 212 degrees Fahr., turned in on the brick. It is obvious that the brick would not crack by exposure to steam, as that would slightly expand the brick, and of course, there could be no shrinkage of the clay, until the steam would be turned off. Then if

dry heat was turned on the brick, no greater than the heat inside the brick, it would only aid and hasten the evaporation of the hot water inside the brick. The surface would not contract but very little faster than the center of it, because the steam inside would keep the pores open, and the shrinkage would be thus equalized, and as soon as the steam would be out of the brick, the whole body of particles of clay would assume at once, their (crystallized) form, and a compact mass unchecked and without crack would be seen.

Now here is the proof of this thing, and I want the old brick burner who generally knows all about the effects of what he does, while not one in fifty of them knows, or ever studies the causes, to mark well my statement here. You know that when you set fire to your kiln, you must necessarily go slow, first, because you cannot make a fire go fast, as you have no draft to make your fire burn. Second, you know that if you fire too fast you will get up such a hot steam that the brick would get soft and "water-settle," but with slow firing the brick become saturated with steam so, as the dry heat follows after, the steam escapes without cracking or water-settling the brick, and the dry heat naturally takes the place of the steam heat without disturbing the cohesiveness or crystallization of the clay.

THE REASON WHY THERE ARE SO FEW SCIENTIFIC BRICK BURNERS.

What are termed the learned professions, are acquired, held and practiced; because all have certain fixed

formula and principles, laid down and recognized as paramount in the use and administration of any particular science. No one would be tempted to practice a science contrary to established principles. There may be novelty in the practice, but the principles must remain intact. Not so in brick burning and making: It is all "hotchpotch" or "hotch pot," as lawyers say, with brickmakers. The public have never asked or deemed it necessary to have a perfect brick made and burned on scientific principles. As a rule, when a job of brick work is to be done, estimates are called for to be made on certain plans and specifications, and the terms "good building brick," "good hard brick," "mercantile brick," or "well burned brick" are employed, without any special or particular qualifications. These terms in common technical parlance, mean, that as good brick as is made in the localities where the work is to be done, or in the market, should be used. The very best in the market may be very bad or imperfect brick, but the builder says, a brick is a brick, and the architect has no formula for a good brick, and many of them do not know a perfect-made and burned brick from an imperfect one, made from the same clay. A brick may look well on the surface, but when broken across the middle, may show only a crust of half an inch that is well burned which shows that the heat necessary to burn a brick perfectly, was not continued long enough to make a uniform hardness, and as most brick are made of clay that will shrink under certain degrees of heat, of course, the surface of the brick, being harder than the inside, there is

an unequal contraction throughout the body of the brick, and the outside is on a strain or sort of tension over the inside, so that a light stroke or uneven pressure will break the brick. It is safe to say that more than half the brick made and burned, are thus imperfect in the quality of strength, and yet we have no fixed rules for judging a brick. We see tabular statements of the strength of bricks to resist pressure, etc., but little or no reliance can be placed on them, as two brick of the same clay and external appearance, may vary in power of resistance to certain given forces, as two or three to one.

The highest possible proof that brick is the most superior building material in the world is the fact, that outside of an occasional job of public brick work, the entire brick work of the whole world is imperfect in all respects excepting perhaps, the purpose and plan of the work, and yet brick are preferred to all other materials for building. Brick can be so made and burned, and then put together with cement, that after a year or more, the mass in any shape would be equal in strength to any kind of stone, and far superior when exposed to frost or fire, yet, as imperfect as our brick work is, it is the first and foremost in real economy and durability. A demand for a standard perfect brick will give us perfect burners.

So long as the general public are satisfied with all sorts of brick there will be all sorts of brickmakers and burners, but once fix a scientific standard for brick, and that will produce the men of talent and capability to produce brick. Supply and demand are the omnipotent regulators of the whole business of the world. If the

option is with demand and he don't get the best that is made, it is his own fault. Brickmaking has been regarded as a sort of a mean, dirty business, followed only by ignorant, vulgar mud larks, ready for a "tough and tumble" tussle at anything; but the art is coming up. Capital and brains must go together to win, and the demand for intelligent brickmakers and burners, will induce young men of fitting capacity to engage in the art with a purpose to master all its intricacies, and understand its various phases. A first-class expert, scientific brick burner, or clay worker of any kind, will take rank in the front of all the mechanical and skilled pursuits. I doubt not that a sort of a university, or school for the practical and theoretical training of the right kind of young men in the clay working arts, would be a great success, and would result in very great improvement to the real economy, efficiency and durability of our best building industry. We want more clay work and less wood work; we want more single tenements, and broader and longer streets to make our cities more healthy and moral. Our rapid transit and facilities for cheap and easy transfer of goods and people, have effectually disposed of the need of narrow thoroughfares, little lots, and high and massive buildings. Fire, health, morals, comfort and all, demand a radical change and it will come.

A brick building for any purpose is much the cheapest in the long run. I have built houses of six rooms with 25,000 brick. I put the outside course of brick as usual, on "the flat," and set the inside on edge,

leaving an aperture of nearly two inches between the brick on edge and outside course. Every sixth course is a "header," or bond course. This wall has two great advantages. First, it is about twenty per cent cheaper than a solid wall of the same thickness and just as strong. Second, yet more important, the hollow, or aperture, is a perfect non-conductor of heat and cold, as well as of dampness. No "furring" is necessary, both "stripping and lathing" is saved and less mortar and a better job of plastering is done, and no "burrow" for mice, or bugs is left, and the liability to fire is lessened. A brick house built two stories high on this plan, is as cheap as a frame house, if the same be done in first-class style of workmanship and material. I have said nothing of the difference in *insurance* and durability. When all advantages are considered, it is a wonder that brick are not used almost exclusively as a building material.

The old prejudice against brick walls, which is mere superstition, would be disposed of by my plan. Everybody could have a cheap, warm, strong, dry, house to live in, and not pay a cent of royalty, as I have built this kind of houses thirty years ago, and don't propose to patent them, beyond the *copyright* of this book.

CHAPTER VIII.

A National Standard Size of Brick a Necessity. The Advantages of a Standard Size of Brick. Size and Quality Should Be Fixed by Conventional Authority. Brick Making and Burning Should Be a Profession. How and Where Can a Man Learn To Be a First-Class Brick Burner and Maker.

A fixed national standard for the size of brick is of so much importance, that the entire brickmaking interests should concentrate in a movement to accomplish it. There are scarcely two manufacturers in the same place who make brick of equal size. There are many serious objections to this unnecessary difference. It has been said that it arises from the difference in the shrinkage in the clay. This is true where the same size of molds are used in different clays, but why not make the mold or die to suit the clay? After one kiln of brick has been made of any particular clay, it is easy to see what size the mold should be, to make a certain given standard size of brick. The best size of bricks for convenient handling, and easy drying, without flaws or cracks, is about $8\frac{1}{2} \times 4\frac{1}{8} \times 2\frac{1}{4}$ inches. This gives nearly 80 cubic inches to a brick which should be the standard size.

THE ADVANTAGES OF A STANDARD SIZE.

1st. Builders could use any make of brick in the same wall. 2nd. The transportation and hauling under similar circumstances would be the same. 3d. A fixed rule could be established for making estimates for brick-work. 4th. The most important manufacturers would not be trying to get the advantage of each other by changing the size of their brick and the buyers and consumers of brick would not be imposed on by having to take a small brick when they expected a large one. There is no advantage in making a large brick. A brick should be made that will dry quickly, heat quickly, burn quickly, cool quickly, and just large enough for an ordinary hand to grasp two. If a man who is pitching brick has to take one in each hand, he loses time, but if he can grasp two with one hand he can work with ease and handle two about as quickly as one. So with the "setter." If he sets skintling or zigzag, he can put down two bricks in right place with one hand. I have often set brick as fast as two pitchers could well and easily pitch.

Two and one-quarter inches is thick enough for a brick. A thin brick will carry more weight or pressure in proportion to thickness than a thick one for the reason that when a brick is crushed by pressure, it will fracture so as to leave a cone, the vertical slope of which will be in proportion to thickness, so that a wall built of thin brick and best cement mortar will carry more crushing weight than one built of thick brick. I would suggest that the National Convention of Brickmakers be held at

some central point and the whole subject of size and manufacture be discussed and decided upon.

A CONVENTIONAL UNDERSTANDING FOR SIZE AND
QUALITY OF BRICK A NECESSITY.

To have the best and most reliable brick work and building, it is of primary importance that some uniform, authoritative rule shall be fixed for the size and strength of a brick, and also for its capability to stand fire. It would not be necessary to fix a standard that would require the best and strongest brick, for it would be impossible to supply the demand. There are, comparatively, few clay beds that will do to make the strongest kind of brick or clay goods of any kind, so the standard brick would have to be such as could be made of fair, average clay of the country, and if better than the standard brick should be needed and required for some special work, the best clays would have to be used. All brick laid on the outside of the wall should have such fire qualities as would stand the heat of a burning building. A well built "party wall," as well as outside wall, should stand fire so that the brick will not scale or shell off. There are many kinds of clay that will stand great heat, but will shell off; such, for instance, as the clay bordering on Lake Pontchartrain near New Orleans, Louisiana. All this kind of clay should be well pulverized and pressed dry enough to go right into the kiln; then it will stand fire nearly equal to good fire brick and the brick are much stronger than if made of soft tempered clay. If brick walls have good foundations and are well built,

they will stand intact after the building is burned, and can be used as at first.

Some architects have said that no wall will stand a fire and be as good as at first building. Most architects know more about drawing a picture of a house than they do about the real, true art of building it. As I said in my first chapter, I am at home on a building with trowel in hand, and I always insist on having my own way about setting joists or any other timber going on the walls. I do not think a man can claim to be a first rate brick layer, unless he can set wood work or iron work on his walls, so that when the building burns down, the falling timber or iron will not pull down the wall. Joists should be cut with a bevel at each end so that there will be a good bearing at the bottom and not more than two inches of the wall left resting on top. If iron anchors are needed, they should be as thin and wide as the joists are thick, and flat on the bottom of the joists, so that when the joists are burned so as to fall, they will hang to the wall and not pry out the brick. Fires all on one side of a wall, will expand and curve it a little, but as soon as cool, if well built, it will re-adjust itself and be as good as when first built. I have said this about the proper use of brick, because there are many good brick that have to stand silent and defenceless, and bear the sins of botchers and the aspersions of novices, and the slander of ignorant and captious critics, who never had sufficient intelligence to get a respectable introduction to a brick.

BRICKMAKING AND BURNING SHOULD BE A PROFESSION.

The public, generally, will never be able to get a first-rate brick until there is a good supply of well trained, intelligent, and thorough makers and burners. The fact that a man be an old brick burner is no guarantee that he can invariably produce a first-class kiln of brick. There are many old burners who look upon brick burning as a matter of luck, and when they make a very excellent burn they speak of it as something out of the ordinary course of events, when in fact, they happened to follow the well known causes which produced their natural effects. If a brickmaker and burner thoroughly understands the nature of his clay and fuel, and how to use both to produce the desired results, he can be as sure of a good burn as of anything else. There is no occult art or secret about burning brick, when all conditions are filled, which an intelligent understanding and good, practical judgment will suggest.

WHEN, HOW, AND WHERE, CAN A MAN LEARN TO BE
A FIRST-CLASS BRICKMAKER.

He can learn any other art at any place where it is practiced, but he may learn to burn brick at Philadelphia, Baltimore, or any other single place, and if he should go to some other place, where the clay is materially different, he would be a mere novice. Then what shall he do to get the art of brick burning so as to be master of it? Until there be a school or university for teaching the art in all sorts and kinds of clay, fuel and

kilns, the only possible way to master the art, is to visit all the good brick factories in the whole country where the clay is different or peculiar in its nature. He could work at each place long enough to see a kiln set and burned. It would probably take him five years, supposing he had the intelligence, perseverance, industry, physical energy and aptitude to thus pursue this art. As I have said before, the phenomena always arising and presented by varied and various experiences in clay-working is so manifest, that it will be a long time before the world will be able to exhibit, or point to a perfectly finished clay worker, but we can have first-rate brick for any purpose if the brickmakers will concentrate their efforts to accomplish the object.

One of the chief faults in the progress of the art of brickmaking has been to consider the making of brick the *primary* object, when, in fact, it is the *secondary*. What is the use of having a brick machine that will make 100,000 brick for \$100, if after the brick be made, they are only half burned? What is needed now to make real valuable progress, is a plan to make a good supply of first-rate *brick burners*. A man may invent a good brick kiln or machine and then not be able to demonstrate it by his own skill. The success of "Dry Press" Machines has been greatly retarded by incompetent brick burners.

CHAPTER IX.

Brick Making and Burning To Perfection Rests Upon No Vague Theories. The Whole Process of Selecting Clay, Manufacturing, Setting and Burning, Involve Certain Principles, Which Must Be Strictly Followed According to Circumstances. Question Of Settling Brick Kilns, Or Shrinking the Brick By Heat. Theory Of Settling a Kiln and Covering With Fine Damp Clay.

It is an old saying that "doctors will differ," but intelligent doctors all agree about some things they have found to be true from long practice and well settled principles. How intelligent, practical brickmakers can disagree about the necessary kind of clay, for a certain specified kind of brick, how they can disagree on the best, proper manipulation of clay for making a certain kind of brick, how they can disagree about the principles involved in the best way to set and burn brick thoroughly, I am at a loss to see. The many vague and speculative ideas I notice by writers on brickmaking and burning, show the great need of some well styled principles and formula for the common guidance of brickmakers. There are various kinds of clay, when chemically considered, but only two forces can be used to make any of

the varieties into a brick, viz: Cohesive attraction by pressure, and crytallization in the drying process by tempered, plastic clay. Now all intelligent brickmakers must know these facts. Now it follows as a corollary, that if the brick are to be made of plastic clay, then the more it is disintegrated and tempered, the better and more perfect the crystallization. It also follows as a demonstrated fact that if brick are to be made of "dry clay," then the more it is pulverized and comminuted or stirred together, the more perfect the cohesive attraction under the necessary pressure. It also follows, that the pressure must be perfect, so that all the particles are completely joined, otherwise the principles upon which the good quality of the brick depends, is only partially carried out.

DRYING, SETTING AND BURNING INVOLVE CERTAIN
PRINCIPLES.

All brickmakers will admit that brick must be dry enough to stand the pressure of about fifty brick, or about three hundred pounds to the brick on edge, before they go into a kiln. They will also admit that brick must be set in such a way and manner, as will allow the heat from the arches, or furnaces, to freely pass up through the body of the kiln, and that any interruption of these features and conditions is a violation and departure from the true principles involved. All good brickmakers further know that only a certain amount and degree of heat can be safely applied to a "green" kiln of brick, and that when a kiln is dried off and the

"fires up," the fires must be increased to a degree hot enough to indurate the clay, through and through, and kept at that heat, until it appears all over the top of the kiln, whether it settles or not. Now, I notice that some writers talk about the practicability of making any kind of clay and that some writers treat setting and burning brick as though all kinds of clay should be managed exactly alike, and put in a little crotchets just by way of saying odd things, such, for instance, as that "there must be three bricks in a 'bench,' five high in the overhangers, and two of these courses tight, then the platting must be put on two courses flat, and first course of green brick, an inch apart, and next, or top, of whole, good burned brick, tight together, except at intervals of five brick, while water-smoking; then if there be a cold spot, the platting to be closed tight (where it was left open) until the cold spots get hot, etc., etc." Now why should there only be three brick "benches?" Why should any of the overhangers be set tight? Why should whole green brick be put on top of the kiln, for first course platting? Why should whole, good burned brick be put on for top course platting? And why should they be put on tight? And why should every fifth course be left out? And, in the name of common sense, I would like to know, why these apertures are to be closed in order to work out a "cold spot?" All these things are old worn-out whims, and have neither reason, force nor utility. I tried them all forty years ago, and was glad to go to their funeral, so far as I was concerned.

THE QUESTION OF "SETTLING BRICK KILNS."

The idea that clay will "settle" when the air is expelled, is vague and without reason. When silicate of alumina, or pure sand and clay is used to make brick, it will stand a glowing white heat without fusing, and if the sand is in excess, a brick will swell. Now, if an alkali or flux be mixed with this clay, it will shrink and fuse just in proportion to the amount of alkali mixed with it. As I have before stated, I have mixed fusible clay with infusible, about half and half, and found the brick would fuse and shrink in burning. I have put two ounces of soda in a brick of infusible clay, and found the brick shrunken after burned. If infusible clay be made plastic, with strong lye water, it will shrink and fuse in a very hot kiln. My clay is infusible, don't shrink or swell, and burns to a cream color. I have put brick in first course below top of my kiln, made of the common red and yellow clay used to make red brick, and when I opened the kiln, the red clay brick was found liquified and run down the kiln. It takes a glowing white heat three days and nights to burn my clay. It may be proper here to repeat the should-be, well-known fact that most all the diluvial and alluvial clays—such as are found on the plateaus and banks of our rivers, are fusible, and will make good red brick, with proper use and burning. It is the ante-diluvial primitive clay, with sand, forming pure silicate of alumina, that is infusible, and will not settle.

THEORY OF SETTLING A KILN OF BRICK.

In all fusible clays, there is a certain quantity of flux, or alkali and iron; when the heat of the kiln is sufficient to oxidize and fuse the flux in the clay, the particles of clay are soldered together, and thus the pores or spaces left in the brick, in the drying or crystallizing process, are contracted, and to a good extent closed, so that the brick is shrunk, and hence the kiln is "settled," as we say. Of course, there will be no "settle" if there be no solder.

TO GET A GOOD, BRIGHT RED BRICK.

In the first place, there must be a certain amount of iron rust, or oxidized iron, in the clay to give a red color, when heated to a certain degree. Second—care must be taken, to see that the heat is not sufficient to fuse the alkaline salts in the clay, as this will give the brick a dark, and iron metallic color. Third—no coal dust should be mixed with the clay, nor coal placed in the body of the kiln, as this will produce irregular heat, and oxidize the iron and salts, and leave a sulphuretted ash color, on the surface of the brick. To make good red brick, the clay must have the right quantity and kind of iron in it, then it must be thoroughly mixed and well tempered, then the brick must be set regular. There should be no large open spaces, nor should there be any obstruction to a free, regular circulation of heat, except the binding course just on the closing course of the overhangers. This should be so tight that the fire will spread when it strikes it. The benches of the kiln, may be four brick, or about thirty-four inches wide, and

should be set skintling or zigzag, open and regular; the overhangers should be set the same. In the kiln, the brick should be set three over three, and if a uniform or face brick is desired, two courses should be set, running same way, thus reversing every two courses, instead of every other course; this prevents fire marks on the edge of the brick, and gives a better draft up through the kiln. One course of platting should be put on top, at least one inch apart, and it may be of the whole brick, or of burned bats. The water-smoking should be slow, the outside arches, especially at the corners, should be kept a little the hottest, This insures good corners and outsides.

No "settle" should be made until the fires are all out on top, and then the heat should be gradually increased, until the overhangers are as hot as they will stand without fusing. This heat should be kept up with careful attention, and as soon as a spot begins to settle, damp, fine clay, should be put on that spot, so as to prevent further draft of heat to that point, and this process of covering with clay should go on, as fast as spots begin to settle, until the whole kiln be covered. As the covering thus proceeds, less fuel and labor is needed, and by the time the kiln is all covered, the use of fuel is reduced seventy per cent. When the kiln is ready to close, no fresh fuel should be added, but the doors should be closed tight, while the arches are hot. A kiln should not be opened until it is cold enough on top to allow a person to pull up platting without burning the hands. Bats and clay should then be carefully shoveled off, and the arches

opened. No one of good judgment and experience, can fail to make good uniform red brick from two or three courses above the arches to top of kiln, if these suggestions are properly followed. The same rule will apply to the setting and burning of clays that do not settle or burn red, only, that a far more intense heat is required, and covering with clay as I have directed in other chapters, being an indispensable necessity, if good brick are wanted. Setting and burning brick, so as to arrive at a uniform good standard for a brick, is of such importance, I will have more to say hereafter on the subject.

I will add here, that if there be any objection to covering a kiln with clay, as it begins to settle or "burn off" in spots, for fear that clay dust will get down in the kiln when being thrown off, the clay can be wet and tempered a little, so as to be a stiff mud, then put on the kiln, treading it, so as to close the platting. This clay should be quite sandy, so that it will not shrink much. This, when thrown off of kiln, will be burned in cakes and pieces, leaving no dust to fall down in the kiln. But I never find any trouble by dust, when I use damp, pulverized clay, about the same as the brick are made of. This plan of covering a kiln with clay, as I have directed, instead of trying to work the fires by closing the platting, or by changing fires in furnaces, or arches, will be found to be of great advantage and benefit to brick burners. It saves at least ten per cent in fuel and labor; it gives complete control of fires, and insures a strong, thoroughly burned, bright colored brick.

CHAPTER X.

Economy in Fuel in Burning Brick. A Kiln With Two Arches Dividing it in Center as Herein Described, the Most Advantageous for Saving Fuel, and Making Hand Brick. Theory of the Excellence of this Kiln. The Ideal Brick Machine for Cheap Brick. To Patrons, Clayworkers and Public Generally.

In former chapters, I have pointed out the different kinds of clay of which brick are made, and of some of the localities where different clays may be found, of the proper way to test clay, and of the different ways of making clay into brick, and of burning them. I will now speak of fuels, kilns, labor saving, and the ideal brick machine, and kiln for the manufacture of a cheap, but good quality of brick, for all kinds of work, except for fronts, or other work requiring a fine exterior.

Economy in fuel, is an important question in brick-making. One thing is certain, we must make and burn a good, strong brick, in order to succeed, cost what it may. It requires a certain amount of heat, according to the kind of clay we use, to burn a brick to any certain degree of hardness. One man may say, "It costs me only sixty cents to burn 1,000 brick." Another, in the same clay, may say, "It costs me \$1.00 per thousand."

Now the question is, which makes the best brick and uses the best skill and economy? As a rule, it is the man that spends a dollar to burn 1,000 brick, and his brick will sell for at least \$1.00 more per 1,000, than those of his neighbor, and thereby makes clear, forty cents per M more on his kiln of brick; both of these men have the same kind of kiln and use the same kind of fuel, and appear to manage the same way; but one, to save fuel, will stop burning before his kiln is quite burned, and the other, will be sure that his kiln is thoroughly burned before he closes it, without reference to fuel; one loses 40 cents per M on his kiln of brick, besides loss in reputation, while the other gains 40 cents per M, besides a good "card" for his brick. But we will suppose now, that these two men, use the same kind of kiln, the same size, and burn exactly the same fuel, in kind and quantity, and yet one of them, will burn his brick so that they will command one dollar per M more than those of his neighbor; what does this prove? Most certainly, it shows a difference in skill, for both, apparently, manage the same way. I presume this statement of a case, in brickmaking, would forcibly apply to all kinds of business, but I know of nothing that shares it more plainly than brickmaking.

We see then, that brickburning is more a question of skill, than it is a question of fuel, or kilns. An unskillful man, may have the best possible way, fuel, or kiln, and not be able to compete with those who have few facilities and great skill. But we will now suppose that all brickmakers are equally skilled, what kind of a kiln

should they use to produce the best possible results? I would say, give me the one that will retain and diffuse the heat most, and has the least side, and end, or perpendicular surfaces, in proportion to the cubic contents.

On this principle, we know that a round kiln, would have less wall surface, than a square one; but a kiln in form of a circle, would not be so well suited to the wants of the brickmaker, as it would to those of the potter. It is more convenient to set in, and get out brick, with a square kiln though the difference in *area* of surface of walls, is about as 38 is to 48; and a circular kiln, say 12 feet diameter, would have 112 feet area inside, while the wall of the circular kiln of 38 feet circumference would only make a square kiln $9\frac{1}{2}$ feet,—85,— $\frac{1}{2}$ feet area, a difference of 26.75 feet, in favor of the capacity of the circular kiln. So that if we could brick in and out of a round kiln, as well as out of a square one, it is clear that we should adopt round kilns. The most economical kiln is that, which comes nearest to a *cube*. If we try this, we shall find more hard, well burned brick, in proportion to the fuel used, than in any other form of kiln.

A KILN WHICH I HAVE TRIED AND FOR WHICH THERE
WAS A PATENT.

To construct this kiln, you will start your walls so as to have, say 30 feet square, clear inside; this will set about 200,000 brick, 45 courses high. You will lay off your arches, or furnaces, so as to give you five brick in length, wide for the "heads," and two brick wide for arches; now let this be carried up, 8 feet thick at bot-

tom, falling off $4\frac{1}{2}$ inches with the offsets on outside, and plumb on inside, leaving a bottom or space from above the arches, of $1\frac{1}{2}$ inches lengthwise from top of arches to within one foot of top of kiln; this will prevent the loss of heat to a considerable extent, by radiation.

Now, when you start your kiln, "setting," you will start a "bench" in center of kiln, at one side, at a right angle with your arches in kiln, the bench will be five brick wide, the center course will be haked tight, and an arch started on each side of it, with benches two brick wide, so that your kiln will have two arches running across it, in the center, and divided by the tight course, haked in the middle, which is carried to top of kiln, as you set it up. After these two arches are started and closed, say six feet back, you will start the arches running transversely from center arches; they will have five brick in the bench, set as I have heretofore directed. They will be set up right over the two transverse arches, from the "heads" back, half way to the tight course, between the transverse arches. So you will proceed in this way, until the kiln is all set up; then wall up the ends of the kiln, after building the furnaces to the transverse arches, and you have the novel kiln, showing two arches running across through the center of it, and six arches, on each side of kiln, running back to the two center transverse arches. Now you will fire, and work the kiln, as I have directed in my former chapters.

THEORY OF THE ADVANTAGES OF THIS KILN.

As I have above stated, this shape for a square kiln,

has the least outside possible. That is one good feature of it. 2nd. You can start your kiln to "water-smoking," nearly all over it, at the same time. 3rd. You can get your fires out, at top, nearly equal, all over the kiln at the same time, and you have good control of your fires, by a center draft across your kiln. If your "middles," are too hot, you can slacken fire a little on, the two crosswise arches. If not hot enough, you can increase the heat in the two, or in either one of the transverse arches. 4th. The distribution of heat is so equal, and the combustion of fuel so perfect, that you can have five brick in a bench with certainty of a good burn, and thereby, have little or no loss by arch brick. 5th. You can burn this kiln as quick as if it was half the width, in the common, rectangular form. 6th. You can have a heavy concentrated, steady body of heat, and while you can save fuel and time, you not only get a larger proportion of evenly burned good brick, but in fact, a more uniform, and stronger brick.

I tried this kiln, and found it a fuel and labor-saver, and where fuel is a large item of cost, I would recommend its use. The patent for this kiln has expired and any one can freely use it.

I said I would speak of the ideal brick machine and kiln, for making a cheap building brick. I do not think it would be a fine brick, but for all exterior and interior work, it would be good and reliable; and with a proper proportion of front brick, would supply any ordinary demand.

THE IDEAL BRICK MACHINE FOR CHEAP BRICK.

I see it working on the rotary principle. The clay is brought to it from a shed, where a large quantity of suitable clay is always on hand. The clay is brought to the machine by an endless belt or carrier and dumped directly into the pulverizer, from which it goes into the machine. The brick comes from the machine, and drops on an endless grind belt carrier, straight out from the machine, to the end of the kiln, where the setting is commenced. This carrier belt is in sections, of about sixteen feet. The brick passes out on this belt in a continuous stream, at the rate of 4,000 per hour. The belt moves over a pulley in the kiln, that is fixed on a movable frame. There are two hands ready to set the brick, two to pitch them to the setters, and two boys to take them off the belt and pitch them to the two pitchers; in all, six hands to handle and set forty thousand brick in ten hours. When the kiln is set up to the belt, a section of the belt is taken out, the pulley is moved back, and the work proceeds as before, until the kiln is done. Then there are two kilns more one on each side of the first, but nearer the brick machine than the first, by the width of the kilns, so that they will not be too close to the first kiln, to be in the way of burning, etc. The end of these two kilns, are at right angles with the belt, and when brick are to be carried into them, a beveled gearing is set at the terminus of the belt, which moves a belt at right angles with the main belt, that carries the brick into the side kilns, and delivers to setters,

as in first kiln, and so the work goes on continuously. By the time No. 1 kiln is burned, No. 2 has been set, and by the time that burned, No. 3 has been set, and so the whole operation of taking the clay from the shed and delivering the brick to setters in kilns, is automatic and continuous, provided, that the burned brick, are taken out of kilns as fast as burned, the kiln should hold about nine day's work of machine, say 360,000 brick. Now let us see how many hands it will take to carry on this whole operation. First, we will put 5 men at getting clay under shed, including 4 carts, call this \$12; now we want 2 good men to put clay on carrier belt from clay shed to brick machine, = \$4; now two good setters at \$5, two pitchers at \$4, two boys at \$2; now an engineer at \$3, a fireman and helper generally, \$2; now a good brick burner \$5, four hands to help him \$8; six hands to take brick out of kilns, \$9; and supernumerary \$1.50, and foreman, \$3, hauling fuel, say \$5; this sums up current expenses for labor and skill, \$63.50. Now fuel, either wood or coal, will cost, say \$40.00 per day; bookkeeper and incidental expenses, \$5; all told for operators, \$108.50 per day. Machinery and kilns, and necessary fixtures will cost \$11,000; clay and ground \$5,000, = \$16,000; call the interest on investment \$5 per day; heat and repairs, etc., \$3, all told, including insurance, \$10, making the total cost of 40,000, \$118.50; making a fraction less than \$3 per M cost, for brick on cars, or in wagons, or carts, the average current market price, would not fall below \$6 M, and this is my ideal brick plant. I have seen all this done, and those wanting particular information, can write me.

TO THE PUBLIC GENERALLY.

"He who lives to accomplish no good for his fellow men, lives not at all," is the motto, which every truly good and wise man should believe in, and be actuated by.

This principle must guide the American citizen pre-eminently, if he is really worthy of that distinguished name and position. Our great and matchless government, is founded on this principle. "It is a government of the people, for the people, and by the people," and its resultant is, "The greatest good to the greatest number." The true spirit in the principle of our government is to enlighten, enlarge and ennoble human nature. If we succeed in perpetuating our government, we must unreservedly hold the "spirit" of it, as paramount to the "letter." The motto of kings, is, "Ourselves first; God and country last." The true, loyal American reverses this to "God and country first, ourselves last." The Ideal of a true typical American, is the man who is rich in noble principles and action. The nobility of true democratic Republicanism, is the true aristocracy, founded on good deeds and unselfish virtues. Our true aristocracy, is exactly the opposite to money, wealth, and oligarchy. See our seventy millionaires, with half of the money wealth of the country, supremely selfish, and ignobly individualized, "reaping where they have not sown, and gathering where they have not strewn." Then look at our half million of *poor inventors*. Their names, their genius, and their achievements are the true source of our great material wealth, and moral force of character. The

man who invents a valuable thing for the material or moral good of his country, is in fact and deed, when compared with the mere "money grubbers," and millionaires, as a "virtuous prince," to a "beggarly pauper." It is from these considerations that I congratulate the improvers in the art of brickmaking.

A great, wise, healthy, good people, must have good buildings, public and private. It is impossible to have them without good brick, and good brick cannot be sufficiently produced without intelligent skill, and intelligent skill cannot be sufficiently grown and qualified without literature, and literature cannot be had and made available without talent and fitness in publishers, such as you fortunately have in the well known, efficient, established, and distinguished "Clay-Worker," and other similar, contemporaneous works. I do not desire to make invidious distinctions, but candor and truth, as well as merited favor and distinction, suggests to me the prominent mention of the "Clay-Worker" in this connection as eminently proper.

CHAPTER XI.

Brickmaking is a Sure, Profitable, Healthy Business, if Intelligently and Energetically Followed. Every Good Brickmaker Builds His Own Everlasting Monument, and Should Press His Name on His Brick. A Simple and Cheap Way to Perpetuate it Forever.

Brickmaking as a business, is one of the most peculiar in its nature and profit, of any business with which I am acquainted. In the first place, it is singular in the fact, that when properly and intelligently followed, it never fails to pay a sure and reasonable profit. I have never known or heard of the failure of a good brickmaker. I do not think that the whole history of bankruptcy in the United States, can show one case of the failure of a good brickmaker, unless he failed at something entirely disconnected with brickmaking. In great bankruptcy years, I have noted the long list of bankrupts, in nearly all kinds of business, and do not remember of seeing one case where a man failed at the brickmaking business. Brickmakers have "gone under," by "going on" paper, but never by "going on" good brickmaking. Occasionally, men, or companies, have got a brick in the hat, who knew nothing practically about it, and would start off to get rich in

one summer, at brick making, but at the end of the season would find more "salmon" brick, trash and bats, than would grace a good, ten year old brick yard, and nothing in "bank" but clay. Of course they have to give up, or get "posted up."

Brickmaking is peculiar again, in the fact that it seems to be such an easy thing to learn—so plain, so undisguised, so simple, so dirty, so rough, so common, so seemingly, requiring muscle without brains, and so uninviting to aspiring minds, that it presents only a field for ordinary minds and plodders. Again, it is peculiar from the fact that it presents only a field for ordinary minds and plodders. Again, it is peculiar from the fact that common, ordinary men do not follow brick making. It takes a peculiar sort of a man to make a good brickmaker. You may take a hundred good, sensible average men; you will get twenty of them that will make good carpenters, or blacksmiths, or brick layers, or plasterers, or painters, or shop keepers, or horse traders, or lawyers, or doctors, or farmers, or almost anything, and especially a quack professor, or a party politician, but you will not find two that will make a first-class brickmaker and burner.

I will not undertake to describe the necessary mental and physical "make-up" of the real, pure full-blooded brickmaker. The best I can say, is, that he is a cross-breed between all extremes, except that he will never pass a good clay bed, or see a good brick, without opening his "blind eye" long enough to make a note of it, or without mentally paying his respects. You can get

ninety well-balanced men any time, (especially if brick is in good demand) out of one hundred good brickmakers. You find no real brickmakers in charity hospitals, in penitentiaries, in dirty politics, or with "Boodler Ringsters." While I am free to say, that our craft does not turn out great statesmen, divines and philosophers, yet I am not so sure, that this absence of distinguished position, is not more to be attributed to the "sublimemodesty, than to a want of talent or capacity.

Brick making is peculiar in the fact that it is not a speculative business. You never see a millionaire brickmaker; his bank is a "clay-bank," and his checks are always honored, and his notes never go to protest, for he very seldom gives a note; he uses John Randolph's, philosopher's stone: "Pay as you go."

A brickmaker is a peculiar man in another respect. It is in the fact that he alone produces the only everlasting, indestructible, and reliable building material on this globe of ours. "Old Time," with his pitiless hand, his remorseless grip, his destroying breath, his ceaseless war, and with endless trophies of victory over all the efforts of man, to withstand his corroding touch and annihilating power, has never been able to destroy a good brick. Every good brickmaker that makes a good brick erects an everlasting monument of his good work. It matters not whether that brick be laid in the laborer's cottage, or in the colossal monument of the great hero, still, and ever, it tells in nature's eloquent tongue of silence, of the modest virtues and worth of the maker.

Brickmaking is peculiarly a healthy business. Clay is the greatest universal disinfectant. It is really nature's great laboratory and physician. It absorbs all noxious poisons. It equalizes the moisture in the soil, and holds its fertilizing properties. But for clay, the world would be an arid, lifeless waste. Instead of brickmaking being a sickly, dirty business, it is the most healthful of all. There is thirty-five per cent less sickness in brickyards, than in any other employment. A brick burner is exempt from all malarial diseases while burning kilns.

Supplement to the Foregoing Chapters. and Direction for their Practical Application.

CHAPTER I.

General Remarks on Foregoing Chapters. Experience, with Intelligent Study and Close Observation, the Only True and Reliable Guide For Mastering Successfully the Art of Brickmaking. Necessary Qualifications For an Amateur Brick Burner and the Proper Way and Place to Begin Work. Proper and Best Place to Fix a Yard. How Clay Should Be Dug.

In perusing the foregoing chapters the reader will have obtained a general and correct idea of clays, brick making and burning ; but unless he has had a sufficient practical experience in brickmaking to enable him to readily comprehend and apply the principles evolved, he will not be able to make brick with any appreciable success. As I have said, the art of brickmaking is more recondite, than routine. It lies hidden in the condition and circumstances which govern the peculiar character of the raw material, and the mode and manipulation employed in the manufacture, and burning. If, for instance, a

man has made brick of clay that shrinks in burning, and then goes to a place to make brick where the clay will not fuse or shrink, he will be "non-plussed;" he will get along as he usually did, until it comes to burning, then he will find that a new apprenticeship must be served before he can succeed. There are so many kinds of clay, fuel and modes of setting and burning that a practical knowledge of each one, together with all the conditions and circumstances surrounding, must be had, before success is assured.

EXPERIENCE IS THE ONLY TRUE, RELIABLE GUIDE.

No amount of book learning will enable a man to make brick; but with the right kind of book study, he can get a good foundation to stand on when he goes to practice. If two men start to learn and practice brick making, one beginning with a careful reading and study of this volume, and the other, with nothing but hearsay, and common talk about brick making to guide him, the one with the book will be an expert in the business, with very little lost in experimental work; while the other one, without the book, will have spent a little fortune, and mis-spent his time in vague and useless endeavor, to accomplish his purpose. Notwithstanding brickmaking has assumed large and respectable proportions, and is making rapid progress towards well settled theory and practice, and, to a great extent, has outlived and run out old primitive methods, yet, in a country so vast as ours, and so sparsely settled, there are yet, and will long be places where brick must be made on a small

scale, to supply the demand of the pioneer settlements; and I propose to point out the necessary work and skill for small operations, and new beginners in brick making, as well as for those who contemplate the establishment of regular, permanent "plants."

NECESSARY QUALIFICATIONS FOR AN "AMATEUR"
BRICKMAKER, AND THE PROPER PLACE,
AND WAY TO BEGIN WORK.

In the first place, the good Lord has not (perhaps for a good thing to brickmakers,) made every man capable of becoming a good brickmaker. To be a successful brickmaker, a man must have more than ordinary physical strength and energy; he must have a sound, deliberating judgment; he must have industry, persistency, patience and endurance; he must be watchful, temperate, and discriminating; and above all, he must want to, and determine to master the art. I am aware that these prerequisites are necessary to success in any proper, honest employment or enterprise; but without these, brick-making is pre-eminently wanting.

THE PROPER AND BEST PLACE TO FIX A BRICK YARD.

After a man has determined to make brick, the next in order, is to select a place. 1st, there must be a bed of clay suitable; then water must be had conveniently; next, of course, fuel must be had without unusual cost and trouble. These matters being settled, the next thing is to get an expert at the business, if you can find one to suit you. That being done or not, you must pick out, if

you can, a high, dry, level spot of ground for a yard or floor to lay out and dry brick on. Stumps, roots, stone, if any, and grass must be cleared off. Then lay off your "floor" in a square form, allowing a superficial foot for two brick; then plow the ground and harrow until level, then take a log or roller, two feet in diameter and four feet long, and hitch a horse to it and roll the ground; then make a "lute," of a piece of two-inch plank, 8 or 10 feet long, hitch a yoke of oxen or two horses to it, and "lute" the surface of your yard, running the "lute" over the yard transversely, several times, until it is well packed and leveled. Now, lay off the yard in rectangular sections, about fifty feet wide, and dig a ditch ten inches wide and four inches deep, dividing the sections.

If you mold brick by hand, you want suitable table, sand box and molds. If by machinery, you must adapt your yard to your machine; but if your clay is to be tempered for hand molding, and it is of a loamy, weak kind, you should have a pit to temper it in, so that you can water it several times during the tempering process. This repeated watering makes the clay more tenacious, and plastic, and the brick are stronger than if tempered by a "pug mill." If, on the other hand your clay is "strong," use a "pug mill," adding sand, if the clay is too "strong." In any case, the clay should be well soaked with water over night, at least.

HOW CLAY SHOULD BE DUG.

First, be sure to remove all the soil off of the top of the clay, then dig a trench, say 4 to 6 feet wide down to

bottom of the clay, throwing the clay out on surface in a pile. Then proceed as before, until you have clay enough for a kiln dug out, and if you expect to operate steadily, you should dig all your clay in fall and winter season, thus your clay is thoroughly mixed, disintegrated by frost and rain, and easily tempered and molded, making a uniform, strong brick. If you are going to use a "Dry Press" machine for molding brick, you should make a shed large enough, between your clay bed and machine, to hold in store enough clay to run your machine all the time, while one half of the shed is being emptied the other half should be filled, so that your machine will always have clay that has been well "sweated" or "mulled."

CHAPTER II.

Molding, Drying, Setting, and Burning Brick.

You have now prepared for making brick; perhaps you only intend to make one or two small kilns to supply the needs and demands of a new settlement, and it is possible that you cannot get an expert to mold, set and burn your brick. If this be your case, it is a bad one; but "necessity knows no law," and if you must have some brick you must do your best to make them. So you must get the best carpenters you have, to make a "set" of molds for you. It will be best to have two brick in one mold, and three molds, making six brick; then have a table and sand box. The table should be about four feet square, the sand box about three feet by fifteen inches, twelve inches deep. Your molds should have bottoms, about one sixteenth of an inch scant on each side; they should be screwed on fast, and should be put under water a few hours before you use them. When you get your mud ready for the table, have a plank $1\frac{1}{2}$ or 2 inches thick, and eighteen feet long, set one end on yard, and the other next to table, on a stool or trestle, so that a man can run up it with a wheel-barrow load of mud. When the mud is on your table, let your boys bring up

the molds, and having your sand box supplied with dry fine sand, let a boy dip a mold full, and shake it in such a manner, as to cover all the inside surface of the molds ; then let a boy put a mold on the table, and if you cannot roll what is termed a "walk," just place the left hand at nearly a right angle with the right, with ends of the fingers together, and cut down a "clod" of mud, about the shape of an oyster, and with a quick but easy throw, fill a mold ; two "throws" fill the mold ; then have a straight "striker," an oval piece of wood, about two inches wide, with which you strike off the surplus mud on top of mold. The boy will now take the mold by the ends, and "off-bear" to the place where he starts a row of brick, and, setting the mold down on edge, will "dump" it, raise the mold, and return to the sand box. Meanwhile, the other boy will have sanded a mold and placed on the table, ready for you to fill as at first ; and so you proceed. One man to mold, and two boys to off-bear, will get out 4,000 brick in ten hours ; and if you have three brick in a mold, will get out 5,000. Your "floor" should hold as many brick, laid out in rows, as a molder will make in three days, so that ample time will be had for drying brick, or room for "hacking" them, until they are dry enough to go in the kiln.

The best way is to have a shed made to put brick under, immediately from the yard, as soon as they are dry enough to handle on a wheel-barrow. They should be "hacked" under a shed, in hacks the entire length of it, one hack at a time, so that the air will freely pass be-

tween the brick. When the shed is full, then the brick should be set in the kiln.

I have thus given general directions for making brick without a machine. In one of the old ways you can have molds made with 2, 3, 4 or 6 brick, and mold the way I suggested—only, that it takes a man to carry four to six brick in a mold. But if you desire to make brick to sell in the market, you will find some of the many machines better than any kind of hand molding.

Setting and burning is next in order, and far the most important, for however well the brick may be made it is fruitless work, if they be not well burned. I am now treating of a case where the maker of brick has had no experience, but is a man of excellent discriminating judgment, and is trying to supply an urgent want of brick in the absence of any possible opportunity to get them. Now, you have made a small quantity of brick, and have them dry under a shed, and you desire to do the best you can to get them burned, so that they will answer your purpose. I will suppose that you have 60,000 ready to set; now select the most convenient spot nearest your brick, and raise the ground with clay or loam, about 8 or 10 inches above the common level; let it be about 30 feet square—filling in well, make it smooth and solid; then erect a shed over it about 22 feet high at ridge pole; this may be done with plank 16 or 18 feet long, with a ridge pole in the center, and an eve pole at each side. Now, you will take a straight edge, twenty feet long, lay it down parallel with shed, crosswise, about four feet from one side, then start the “bench,” for out-

side, one and one half brick thick ; set the brick apart so that three on edge will take the length of one. The bench will show alternate courses of "header" and "stretcher" on edge, five courses high. When this is up and straightened, you will place two brick flat at each end, out from the bench, put your straight edge on the outer ends of these brick, which gives you a space seventeen inches wide, for the width of your "arch;" now, you will start with a brick on edge, as at first, with end against the straight edge; you will set the ends of bench up, in block, with end wise of brick reversed; (this is termed "heads") then set between "heads" the first course of "bench." These are set a little zig-zag, or "skintling," as it is termed. The brick are set diagonally, like a narrow x, diverging from a parallel line, so that one brick set on edge, on top of another, will diverge from parallel lines of the two brick about two inches, or thickness of a brick. The brick must be set open or apart, about three-fourths of an inch. Set one course at a time, and straighten it with a straight edge. Set up two courses, five high, then start overhangers on outside bench. Set up outside plumb and put overhangers on at same time, until you get on five courses, the last of which will project to center of arch, then start everhangers on inside bench, carrying up two courses wide same as bench until the two courses of overhangers meet; then put a course on as a "binder," tight, right over the closing of the top overhangers; this is the only tight course in the whole kiln. Then proceed to set two more courses as at first, in "bench," making "bench"

four brick wide. This done, you will then put on "overhangers" and carry up all courses together as before, then put on one more binder, set open, then start "running" course across the kiln, setting open, "three over three." There should be no tight courses in the kiln, except the one over the meeting of the top "overhangers;" this causes the fire to spread, as it rises out of the arch. Now, having set the first arch up thirteen or fourteen brick from the bottom, you will start on the outside, and set it up three or four courses wide, three brick over three, taking care to set up "heads" straight, but "battering" or leaning inward about one-fourth inch to every brick in height, so that the kiln will be at least sixteen inches narrower on top, than at bottom. Carry up outside arch, 24 brick, then set off a half brick, put on binder and set six courses higher, making kiln from bottom to top, thirty-two brick high; now put on a course flat, as "plating," one inch apart, if of whole brick; this completes setting of first arch; now proceed as before, until the whole be set up, which you see will make four arches. Now having set up your kiln, you will proceed to incase it. To do this, for present use (for it is all temporary), you will make "center" or segment of a circle of strips of inch plank, 2 in. wide and 3 feet, 10 inches long. To form the segment, take two pieces of one-quarter inch plank, four and one-half inches wide, one piece eleven inches long, and one ten inches; cut one edge of each piece to a circle to rise in center the width of the piece; then nail on the strips, which will form a "center," to turn an arch over; set the large end next to the kiln, one inch

off, in the center of the kiln arch ; set it on loose brick, so that the top of center will be 20 inches above ground ; set the out end seventeen inches above ground ; this makes the arch, or furnace of kiln, an inch smaller on outside in width, and three inches in height. Now having "center" ready, make up some very thin mud of loamy clay ; lay down the side walls of arch, nine inches thick, of unburned brick in mud ; then, when at height of lower part of "center," clip one edge off "green" brick to suit the circle, and turn arch over center, one brick thick, then another, so as to make the arch as thick as the abutments. The brick must be laid in soft mud, and joints well "flushed." Now proceed and put a like arch or furnace, to kiln arches, on both sides. Your furnaces all done, you will start a wall of dry "green" brick and bats nine inches thick between the furnaces. Carry it against the kiln about six feet high ; then put on a heading course on edge ; then start a wall on that, one brick thick, and carry it up to the top of the kiln ; then wall in like manner between front of furnaces, and "daub" or plaster the whole well with soft, thin, loamy mud. Now you are ready to fire the kiln.

SETTING FIRE TO KILN AND BURNING.

You will probably need twenty-five or thirty cords of wood. If you have, or can get, one-third of that green, it will be better than dry wood to start with, and "water-smoke your kiln. You will lay two sticks of wood in each flue, or furnace, and start a slow fire, keep-

ing only just wood enough in the furnace to make a fire. You will keep up this slow firing two or three days, if your brick are not very dry in kiln. As the "water-smoke" ceases at each side of kiln on top, and the platting gets hot, you will increase the fire, occasionally pushing back coals and fire brands. In three or four days, if the brick are not very wet, the "water-smoke" will disappear, and a red heat will follow on top; then you will increase your fire, by keeping your furnaces full of wood, and sliding over the brands. The "overhangers," in arches, are now at a bright, red heat, and the fire is out all along the "heads" or sides of kiln, and will soon appear on top clear to the middle of kiln. Now you will keep your furnaces and arches at a steady, strong, glowing heat, and if the clay is fusible, you must watch closely and often, the effect of the heat on the "overhangers." If you see the lower corners begin to "drop," slacken your fires a little, and when you have just the heat that the clay will stand, keep that steady and regular, until you see your kiln begins to settle. As soon as a spot, or part begins to settle, if the fire be out strong and bright, showing a sulphuret on the platting, get a bag or bucket, and fill it with damp fine clay, and cover that spot, and as the platting becomes sulphureted, and the settling appears, cover with clay about one inch deep, spreading it with your foot, until the whole kiln be covered. If the clay your kiln is made of will not melt, but will stand all the fire you can give it, you will keep up as strong a heat as the combustion of your wood will afford, until you close up your arches, which you

will do by filling the mouth of the furnaces with dry brick and daubing with soft mud. With these directions, and what I have said in the foregoing chapters, any man with good, practical judgment, and industry, can make and burn a kiln of brick that will answer the wants of a place, where brick cannot be had from regular practical brickmakers.

CHAPTER III.

Brickmaking as a Business. Choice of Brick Machines. Having Decided on a Brick Machine, the Next Thing is an Expert Brickmaker. Gain by Using Exhaust Heat of Kiln Just Burned. The Way to Obtain Experts in Setting and Burning Brick. Brick Laying and Economy in the Use of Brick. Making Mortar for Laying Brick. Importance of Laying Brick in the Best Manner. Good Brick Work and Good Brick Should Go Together. Importance of Good Foundations. A Universal Size and Quality of Brick Needed.

As I have before said, until within the last few years brickmaking has been conducted on no fixed principles. Any man with plenty of money and self-conceit and a modicum of practice in a brickyard, might start out as a brickmaker; he could partly imitate what he had seen others do, and by adding his own vague notions, could make a sort of show of business. What he did not know, he could supply by employing some ignoramus who had learned the routine practice of some old, antiquated brickmaker, and the result would find an establishment that would turn out two bad brick to one good one; and the proprietor being ignorant of the true theory and practice of the business, his efforts to improve it were

apt to be suggested and guided by some one like himself; so it was the "blind leading the blind."

A great change has been effected by the influence of the immense demand for brick, and the rapidly growing interest and knowledge of what a brick should, and must be, in order to supply the demand, and to compete with the few who have learned the science of brickmaking, as well as the practice. Brickmaking is, therefore, a question, of not who has been longest at it, but of who has the most intelligent, practical knowledge of it. If long service at brickmaking were the only test of proficiency, perhaps I could claim to be one of the best, if not the very best brickmaker in the United States; but if I had not studied and carefully practiced the business, my long life, and varied practice in it, would count for little in the sum of progress. When a man or party decides to engage in the manufacture of brick, the first question to decide is, as to clay and locality. This being settled satisfactorily, the next is, what kind of machinery is best adapted to the clay? Where there are large beds of "homogeneous" clay, suitable for brick, and the clay is pulverulent, or easily reduced to a powdered condition, I would say, by all means, get the best "Dry Press" machine; on the other hand, if the clay be of a "heterogeneous" character, I would say, get a machine that will make "plastic" or semi-plastic" clay brick. If a very fine face or front brick is needed, well tempered plastic, or semi dry clay will give the best result, especially as it regards color. I have made beautiful front brick by dry dress machinery, but I could take the same clay,

in a plastic or semi-plastic condition, and make a more natural, bright color. True, a dry pressed brick may be so finished, by an expert, with the right kind of sand brushed or rubbed in, on the face of it, with proper care, when in a damp state, that it will compare well with a plastic clay brick ; but it will fade quicker and more by the action of weather and time than the brick made of plastic clay, for the reason that the mineral oxide in the clay, which gives it color, has been more thoroughly distributed by watering and tempering, but if clay be well soaked, tempered and dried, then pulverized, and dry-pressed, the color will be as natural as if molded in a plastic state. I have made dry pressed brick of "green" bats of tempered clay, that showed a perfect, natural color, through and through.

HAVING DECIDED ON THE QUESTION OF MACHINERY,

The next thing to consider is, the necessity of a good, reliable expert, in setting and burning brick—and here is a "poser." I think one of the hardest things to find, is a thoroughly competent brickmaker—the supply is not half equal to the demand. Indeed, a thoroughly competent brick setter and burner, is a rarity seldom to be met with, and will continue to be so, until improved methods of burning and facilities for learning are so increased and formulated that young men can readily avail themselves of opportunities, ample for study and practice, until the art has been acquired and sufficiently mastered to insure success.

That such facilities will be offered, I have no doubt.

Demand will bring supply; and the brickmaking industry has assumed such large proportions, that the establishment of a *University Manufactory*, at some central point, where all kinds of clay, and the best established modes for successful manufacture, will be regularly and systematically practiced and taught. But I am here addressing men who cannot wait for these things; you are ready to make brick now, and you must have them properly "set and burned" if you are to succeed. So if you are not an expert yourself, get the very best one you can.

The first two or three kilns should be small and experimental, noting with precision, the setting, the fuel, the action of fire on the clay—in short, all the varied conditions, circumstances, and manipulations of the work. After one kiln be burned, you can see the faults and mistakes made; of course, you will not repeat them in your next kiln, and will likely be able to see how to improve on your first effort. There are many new kinds of kilns for burning brick, and it would be quite out of place here for me to be invidious enough to single out any particular invention, and say that is the best. Nearly, or quite all the patents I have noticed for improved brick kilns, have some good features, and several appear to be successfully working; but, after all, as I have stated in some of the foregoing chapters in this book, burning brick is not so much a question of economy in fuel, as it is of efficiency in producing the best brick. The kiln that turns out the largest percentage of best brick, at any reasonable cost, is the best kiln. I have discussed this question in the preceding chapters,

and will only remark here, that the greatest economy in burning brick is not to be attained by any particular construction of kiln unless it embraces the principle of continuous burning; or, in other words, a kiln that will transfer its exhausting heat, after it be burned, to an adjoining kiln, so as to "dry it off," and partially heat it. This, I am sure can be done; but unless the brick could be sold and delivered as fast as burned, the advantage of continuous kilns would be lost, for it would cost more to remove and keep the brick in store, than the gain in fuel would amount to. Still, I think the waste from a kiln, just after it has been burned, can be utilized with profit, even without any considerable cost over the common way of burning.

GAIN BY USING THE EXHAUSTING HEAT OF KILN.

All the advantage that could be gained by using the heat evolving from a hot kiln of brick, after it has been closed, would only amount to about twelve per cent., saving of fuel, for if we attempt to cause a draft that would carry off the heat any faster than is taken up by the natural absorption of the atmosphere, we naturally injure the strength, color and tenacity of the brick. I have found by long and repeated experiment, that if a kiln of brick be exposed to draft of cold air, until the top has become cold enough to allow brick to be taken out, without being too hot to handle, that the real value of the brick is much impaired. I have treated of this subject in the foregoing chapters, but will add here, that it would be impossible to produce a first-rate brick without covering the

kiln tight with clay or brick ; and, therefore, to allow the exhausting heat from a kiln to pass off by any kind of draft that would make the heat effectual in "drying off" another kiln, would be to seriously damage a hot kiln, and do but little good to a cold one. So that the question of fuel-saving is not to be considered if it involves the good quality of the brick.

CONSTRUCTION OF KILNS TO PREVENT WASTE HEAT.

In the common kiln, no means is employed to prevent the great loss of heat by radiation. A solid wall of varied thickness is built with no non-conductor of heat, and the consequence is, that every time a kiln is burned, the whole mass of material in the walls is heated, which takes about ten to fifteen per cent. of as much heat as is used in burning the brick. At least half of this loss could be saved by using a non-conductor of some kind, in constructing the walls.

We will suppose that we want to construct a kiln for 250,000 brick ; this would be about forty-four by twenty-five feet in "clear" dimensions ; it would be ten arches, four brick in a "bench," and two in "arch;" outside "benches" one and one-half brick ; this would be about fifty feet by thirty-three feet on outside at the bottom. The walls would be about seventeen feet high. After these walls are carried above arches, an open space of one and one-half or one and one-fourth inches should be left in center of wall, lengthwise, to within one foot of top, when it should be closed over solid, excepting openings, thickness of a brick, and six inches wide, and one

foot apart from open space to kiln. The side walls should be four feet thick at bottom, and should be plumb on the inside; but should set off four inches every four feet in height on outside. At every fifth course, a "header" or "bond" say fifth course, may cover the open space in middle of wall, but should be laid a half inch apart, so as to let air pass freely. This would prevent the excessive radiation of heat from the outside of kiln. A kiln constructed in this way, and the top of kiln closed tight with clay when burned, as I have before directed, is within a fraction of the very best economy and efficiency yet known or attained. by any kiln of more length than width. This kiln will perfectly and economically burn any kind of clay, while many of the recent patents are for kilns adapted only to certain kinds of clay. The kiln above described may be built of unburned brick, after carried up above the furnaces, excepting the outside four inches, which should be of burned brick. The unburned brick may be laid dry, without mortar, and close together, as no open space is needed for non-conductor, if laid without mortar, with "bond header" every third course. If done in this manner, the inside should not be "daubed" or plastered, until one or two kilns are burned in it; then it may be daubed as usual. The burning of two kilns will burn all the unburned brick in the walls, to a good "salmon," and if the kiln be "daubed" every time before the brick are set in, it will do about as good work as if all built in the regular way of burned brick. I burned 5,000,000 brick, mostly for U. S. Gov-

ernment, at one place, in kilns of this kind. I found these kilns to be as good as if built of burned brick; and when I quit the place I sold the kilns, as "salmon brick."

Where fuel is scarce and costly, a kiln for continuous burning may be constructed on very simple and economical principles. I have made some satisfactory experiments in this line of improvement, but as yet I have found fuel such a large item of expense, as to make a continuous kiln desirable. As I have before stated, continuous burning in one, or a series of kilns, would necessitate the handling of brick one time extra, unless sales and delivery from the kilns direct could be regular and continuous.

THE WAY TO OBTAIN EXPERTS IN SETTING AND BURNING BRICK.

The only way to get a supply of anything is to offer a fair or tempting demand. So long as the demand offers no inducement to brains with competent skill and energy to handle a brickmaking establishment, just so long will we have "botches" and "bull-heads," to set and burn brick. And just so long as the people and general public are satisfied with a slipshod kind of builders and building, and will take and buy any kind of a brick because it is cheap, just so long there will be a demand for half-way brickmakers. We must fix, by some conventional means, a higher standard for quality of brick; and then a demand for a higher quality of experts will be the rule, and young men of suitable capacity will engage in the business of brick setting and burning as a

profession, as in law or medicine, or other professions.

BRICK LAYING, AND ECONOMY IN THE USE OF BRICK.

Brick laying, unlike brickmaking, is a "routine" art. Teach a boy once to lay brick, and he will be able to do it anywhere; while a brickmaker will have to learn to burn brick every time he is called to manipulate a different kind of clay from what he has been accustomed to work; but bricklayers are incidentally a very important element in the brick industry, and economy of building.

While there are many honorable and meritorious exceptions, yet as a rule, bricklayers do not study or know much connected with their business outside of the mere use of their tools, and a careless, unintelligent use of the materials in hand. With the average bricklayer, a brick is a "brick," lime is "lime," and sand is "sand." Not one in twenty can tell what kind of clay a brick is made of when they look at it, nor can they tell if one is improperly made, or not. They will buy a barrel of lime and make it into mortar, but for the life of them, they cannot tell you just what kind of mortar it is, or how it will act under atmospheric changes. They will get sand apparently good, but when tested properly, is really very bad. Then will make up a fresh hot bed of mortar; then, with brick dry and warm, that will absorb one fourth or more, of their own weight of water, they will start a wall. Of course, the brick at once absorbs all of the water of crystallization in the mortar and nothing is left to cement the mortar and brick

together, and a wall of anhydrous brick, lime and sand is hastily run up, which can never have any adhesive strength, or solid body, any more than a pile of dry brick and ashes. What is the use of insisting on having a good brick, if laid up without proper care, and good cement? It is, therefore, a matter that deeply concerns brickmakers, to have their products well and rightly handled, so that they will have a fair chance to stand upon their true merits. We often see tables of test, made to show the resistance of brick to crushing weight. How could such test be fairly applied to the front wall of a building put up in the ordinary way? All the weight of the wall is on a small proportion of the brick. The bricklayer will pick up a brick in one hand, and with his trowel in the other, will, by a peculiar expert movement of his trowel, take up a little mortar on the bottom side of it, and, what he calls "butter" the edges of the side of the brick, which is to lay on the wall; thus, the "bed side" is not properly "bedded," as the mortar on the front side does not cover more than an inch wide, along the edge, and on the back side, only perhaps two-thirds of the edge has any mortar on it, and this is called first-class work. The reason of this wrong departure from the old way of spreading the mortar on the wall, and then settle the brick to the line, in a perfect bed all over the surface is, that it is much easier to settle a brick to a line to a thin joint, when there is a very little mortar under it. It is the expedient of the "botch" to show a fine joint, without the skill to do it in a workman-like manner, and properly bed his brick. It

is one of the shifts of modern show, to show a fine front, and is only a piece of the sham practiced generally in all things.

GOOD MORTAR AND GOOD BRICK SHOULD GO TOGETHER.

If a good, substantial job of brick work is to be done, a large vat, about four feet deep in the ground, should be made of plank, which should come up to a foot above the surface; it should be nearly water tight. It may hold from twenty, to three hundred barrels of lime. A "slaking" box should be made to hold several barrels of lime. One end of the box should rest on the vat, and water should be convenient. The box should be partly filled with water; then the lime should be scattered all over the box, and when it begins to slake rapidly, it should be well stirred until done slaking; then it should be let out in the vat; and this process should go on until the vat be filled. Water should be kept at least two inches deep all over the surface of the putty in the vat. After three or four weeks this putty will do to use; but it improves by age, and two barrels of lime run into putty, and properly kept six months, will make more good mortar, than three barrels used just after "slaking." This is the proper way to keep lime in store, instead of letting it air slake. The putty is always ready for use, and can be handled even better than quick lime in barrels. It will not "set" or "crust" under water, because the carbonic acid of the air does not come in contact with it. The difference between the common lime mortar, and hydraulic cement mortar, being, that common lime is only carbon-

ate of lime, while hydraulic cement, is silicate of lime, or silicic acid, lime and alumina; the one absorbs carbonic acid from the air, and becomes hard, or "set," and the other absorbs silicic acid under water, as well as carbonic acid in the air. If a brick, containing a large portion of sand, be pulverized to an impalpable powder, and then mixed with one-third of its weight of good lime putty, it will "set," or harden under water. All common mortar for brick houses, should have hydraulic cement added as the mortar is carried on the "scaffold." For this purpose temper up, say, nine buckets of mortar, ready for the bricklayer; then add one bucket of hydraulic cement; stir all well together, and carry to workmen. If now, the brick layer will have his brick wet or damp, and spread his mortar so as to bed the entire surface on the joint, taking care to "throw on" good flush joints, with bond of "header," and "stretcher," properly laid, his wall will be as compact, strong and entire, as a stone of the same dimensions.

As I have said in a foregoing chapter, a two-story house can be well and safely built of wall nine inches thick, with a brick on edge inside, say three courses on edge, then a heading bond course. This leaves an air space, which prevents dampness from outside. The inside of walls are thus kept dry, and are made stronger, by being plastered without "furring." A house built this way, with mortar and work as suggested, is better and stronger than one with twice as many brick, put up in the ordinary way.

IMPORTANCE OF GOOD FOUNDATIONS.

I have seen a fellow start out "boss builder," take a brick house to build on the side of a hill, start the lowest point, about one foot below the surface, and dig a trench back, sixty feet long, on a level, so that the foundation of the front of the building would be one foot below the surface of the ground, and the back front, six feet below the surface. Two years after the building was up, I noticed that the front part of the walls had settled, and cracks were seen from top to bottom, and iron anchors had to be put in walls, to keep them from falling. This is only a specimen of defective foundations, which, in fact, may be found existing, in some way, in a majority of buildings. I have no space now to go into the matter, prerequisites, and ways of getting a good foundation, but with science and skill, a good foundation can be had anywhere; but it has been urged as a drawback on brick building, that at some places, good foundations could not be had. I have built large brick buildings on sand, on mud, on sliding marsh beds, and on inclined planes of rock, and in no case, have failed to secure a good foundation. When we fairly and duly consider the many advantages of building with brick, we can not fail to recognize the great importance of making brick, in quality and quantity, so that the general public will at all times have a good supply, equal to the demand. Stone, iron and wood must give prominent place to brick. Stone is only suitable for underground work. Iron is only fit for some subordinate place in brick work. It

will do to prevent unequal strains, and thrusts in brick work, but, as a chief building material, it has utterly failed in every well tried experiment. As to wood, at best, it is only to be considered for temporary use, and if we take fire, decay and insurance into consideration, wood is the most expensive of building material.

There has been an effort to make concrete and cemented material take the place of brick, but that is only an experiment without reason, or good results. Brick can be made and put into a wall cheaper than any other material; the raw material is cheap, boundless and various for all purposes of clay work, and everywhere obtainable; and the time is not far distant when brick will be the universal building material. The hollow brick idea has had some consideration, and I made some experiments in that way. I found the extra trouble in making and handling, the liability to break, and their want of adaptability to all sorts of work and places were serious objections to their general use and profit.

WE WANT A UNIVERSAL BRICK IN SIZE AND QUALITY, and a nomenclature for the same. Eight and a half inches long, 4 1-16 inches wide and 2½ scant thick, would be a proper size for a world-wide brick. This size is convenient to handle at all times and places, and brickmakers could adapt their machines to their clay to make this size, with scarcely any variation. Then a brick, like a dollar, would be a brick in every market. A universal standard size is almost an imperative necessity.

I will say to the reader, in conclusion, that I have

written this book, as the results of my own personal practice and experience, and not from any hearsay and assumption, on the theory of others. Whatever I have quoted is properly credited, and only refers to matters of well-known science.

J. W. CRARY, SR.

**SPECIFICATION FOR BUILDING AND USING
THE BRICK KILN, AS SHOWN ON PLAN.**

FOUNDATION.

Foundation to be dug out to solid ground, and well rammed so that there will be no settle of walls.

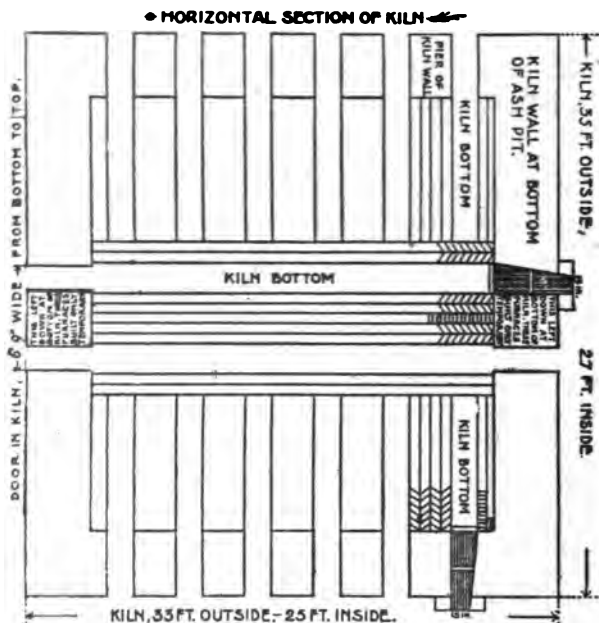
WALLS.

The bottom wall will be eight brick in length wide, and will diminish to six brick, having four two-inch offsets on each side, then built up as shown on vertical section of plan. Wall will be hollow, having an open vertical space of $1\frac{1}{2}$ inch wide as shown on plan. At top of this space there will be horizontal openings every eight inches, so as to let the hot air in vertical opening, out against top of kiln.

MATERIAL FOR BUILDING KILN.

If enough burned brick are not on hand, and you wish to economize get enough burned brick to build from foundation to first offset. Then use burned brick on outside of wall, and well dried unburned brick on the inside. The outside to be laid in lime and sand mortar, the inside to be laid dry without mortar, every third course a header, or binder, laid about a quarter of an inch apart.

The inside to be bound at every fifth or sixth course to outside header, but no hollow space to be left in middle, as if built with all burned brick and laid in mortar, for the reason that the unburned brick being partly open and



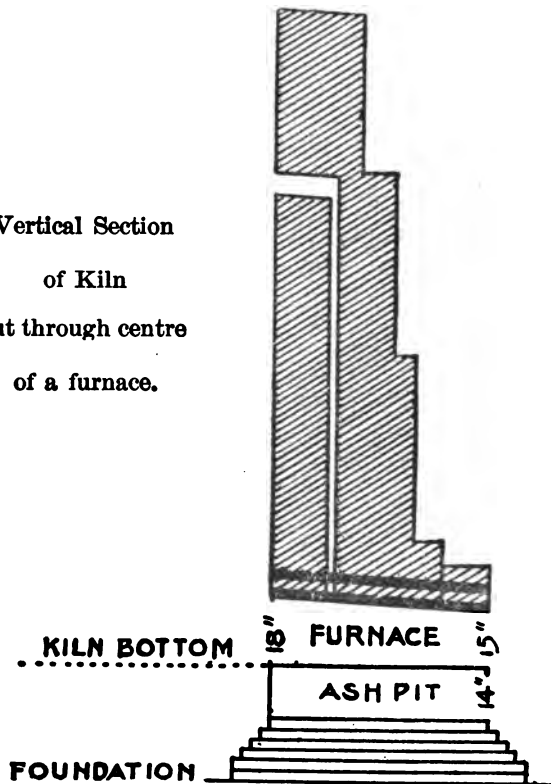
loose, will get burned after two kilns are burned, and then the inside being daubed with sandy clay grout, as it should be, the walls will be sufficiently open to prevent heating through; that being the object of the hollow in solid wall, so as to save heat.

NOTE—Doors of kiln at transverse arches can be arched over, 7 or 8 feet from bottom of kiln if desirable.

FURNACES.

The furnaces will be arched over with two 4 inch arches of fire brick, of size and dimensions in plan.

Vertical Section
of Kiln
cut through centre
of a furnace.



GRATES AND DOORS.

The grates will be $2\frac{1}{2}$ feet long, and cast thin, say $\frac{1}{2}$

inch, they will set on bottom of kiln pavement inside, and on a bearer of iron from in the middle of the furnace, and outside on door of sill, making five feet long of grate surface. Doors will be set with upper and lower shutter, the upper shutter will have three holes in top one inch in diameter, so as to admit cold air to aid combustion of gases from fuel.

SETTING THE BRICK.

The cross, or transverse arches, should be started first, and set up to binding courses, say twelve courses high, and set out about six feet; the center bench has the middle course set tight, or nearly so, as shown in the plan, and should be carried this way to top of kiln. After six or seven feet of the center arches are set out, then start the arches on each side, as shown in plan. They will be set out over the cross arches and carried up to top of kiln, and the center course of the cross arches carried up at the same time.

In setting the benches, "overhangers," and the two binding courses, it is best to set the brick skintling, or zigzag, as in plan. The brick should be $\frac{1}{4}$ of an inch apart except the course just over the closing of "overhangers." This single course should be set tight, so as to spread the fire into benches. If the setters are not skilled in setting skintling, they can soon learn by setting a few brick on a plank $8\frac{1}{2}$ inches wide for experiment, and when setting arches of kiln, use a straight edge board, straightening every course. If the whole kiln is to be set skintling, one course should be set up at

a time, as high as a man can reach, then when he gets up on bench to set up to top of kiln, he should also set up one course at a time. This makes it easy to set, and the setter can carry the work straight. The skintling style is best from bottom to top, but if the old way is preferred, after setting the arches, let it be done. But if the brick are over $2\frac{1}{4}$ inches thick by $8\frac{1}{2}$ long, it is best to set five over the length of two, instead of three over three. A kiln of brick cannot be well burned unless set loose, and regular from bottom to top, excepting the tight courses I have specified.

BURNING.

All necessary instructions for burning will be found in this book, elsewhere, but I will add here that if coal is to be used only, grates may be set so that fire be put further back, making a grate surface of ten feet long, but if wood can be had, I would use it to throw back, instead of coal. Soft coal will burn on a hot bottom if often and well stoked, and may be used instead of wood. But all intelligent brick burners will recognize the fact that the main heat must be generated in the furnace, outside of kiln, and it is simply a question of combustion and draft. In order to get this and the best heat, the benches and overhangers must be set loose and skintling, and the whole body of kiln must be set open and regular. This will insure a good draft in the furnaces, without which, brick cannot be thoroughly burned. The draft can always be regulated by covering with fine damp clay, as I have elsewhere in this book directed. The

moment that a spot or place in the kiln be well burned, cover it with clay. This saves wasting heat and drives it to the places wanted, and so proceed with covering as fast as places are burned, until the kiln is burned and covered. This gives complete control of fire, saves fuel and labor, and insures uniform, strong, well burned brick throughout kiln.

In constructing this kiln it is not necessary to make it as large as the plan. If a smaller kiln be wanted, four arches or furnaces on a side will do, and the kiln may be set thirty brick high only, if a small kiln be desirable. If a larger kiln be needed than is shown by the plan, it may be extended so as to make seven arches instead of six, or if the clay will stand fire well, all the benches may be five brick wide instead of four. This would add one-seventh to the capacity of the six arch kiln on plan.

I will repeat, that covering kilns with clay, as I have before directed is of primary importance. There is no other feasible plan for controlling the fire and draft, saving fuel and labor, and equalizing the heat throughout the kiln, so as to insure thoroughly burned, tough, strong brick. Clay for covering, should be of a loamy kind, pulverized so that there will be no large lumps, and should be damp enough to cohere if pressed in the hand. It may be taken up on kiln and handed to the person covering, in a small sack or in a bucket; when it is dumped on kiln it should be spread and pressed down a little with the foot. The covering should proceed as fast as places are settled or burned, until the top of kiln be covered. The fires should be kept up in furnaces until the

"settle" is even, all over the kiln, or nearly so, then close as I have before directed.

APPENDIX TO SUPPLEMENT.

"WHITEWASHING" IN BURNING, THE CAUSE AND THE CURE.

It is a well known fact to all old, well experienced brick burners, that, when the fire is pushed too fast when a kiln is "water-smoking," and the outside of the brick becomes red hot before the inside is clear of water, that the surface of the brick is coated with what is termed "whitewash," and that if the kiln be "closed," before it is thoroughly burned, this "whitewash" will remain a long time on the brick. Now this "whitewash" is a sulphuret, or efflorescence from the minerals in the clay, which has not been sufficiently oxidized to expel them. This is one of the difficulties in burning oil with steam in a brick kiln. The combustion is rapid and the surface of the brick is enveloped in a hydrated flame, and unless the heat is made intense and kept up until the brick is thoroughly saturated, and the volatile minerals oxidized and expelled, the brick will have a motley, whitish appearance on the surface, and if broken across, will show the various degrees of heat that the brick was exposed to while burning.

It is, therefore, best to use oil without steam or water, and force a spray of oil through a perforated nozzle, into

furnace, or else saturate "pea coal," or fine split wood with it, and burn it on the close grates. This, I think, would be the safest and most economical way to utilize both oil and cheap coal, taking care to follow my directions for burning, in foregoing chapters.

NOTE.—I do not refer here, to the miscalled whitewash, which is seen on red brick fronts, as for instance in Philadelphia and Baltimore, as the frost comes out in early spring time. That is an efflorescence of potash, or pearl ash, in the brick. A coat of linseed oil will dissipate it and restore the color of the brick.

"THEORY AND PRACTICE OF BRICKMAKING."**BY J. W. CRAEY, SR., BLUFF SPRINGS, FLA.****Fellow Workers and Gentlemen of the Convention:*

Your worthy corresponding secretary has done me the honor of inviting me to be present at your convention, and requested that if I could not attend that I should supply my personal absence by a paper on the "Theory and Practice of Brickmaking." It is a very easy thing to write papers, but the great difficulty is to have something to say. If all of the thousand tons of printed matter published every month in the United States were boiled down to first-rate common sense, there would be nine hundred tons of "skimmings" and one hundred tons of good, digestible, healthy matter left for the consumption of common sense people. I have no doubt that much I write would have to be well "boiled and skimmed" before it would be palatable to healthy appetites. But as brick-makers are not, as a rule, very fastidious, dainty fellows, I will not further trespass on your valuable time with apologies.

Standing at the head of one of the oldest arts in the world, gentlemen, you can feel assured that you are not

*Paper read before the Fourth Annual Convention of the National Brick Manufacturers' Association.

dealing with some untried, doubtful scheme or device, when you propose to furnish the world with the only building material that will best serve intelligent men, and stand the test of weather, fire and time.

It would be superfluous to recapitulate the historical manufacture, kind and use of brick. Suffice to say, that until within the memory of men now living, brick were made by hand, of soft, tempered clay, dried in the sun, and burned in the old-fashioned "cased and daubed" kilns. In such a style I first learned to make brick. Altogether, it was a hard, slavish process; about the same as it was under the Pharaohs in Egypt, who kept the enslaved Jews exclusively at brickmaking, and these peculiar people got such a long, strong dose of brickmaking that it has not done operating yet, and you might as well offer a Jew pork to eat, as to offer him "stock" in a brickyard. A Jew never looks at a brickyard without cursing Pharaoh, and thanking God for the Passover.

I can well recollect about the first attempt to improve on the venerable, gray old art of brickmaking, and, strange to say, it was not a gradual innovation. It was not from soft mud to stiff mud, or from stiff mud to semi-dry pressed, but it was from soft tempered mud to dry clay. This was a long, blind stride. It was, as the learned say, going at it "aposteriori" instead of "apriori."

It was assuming the fact without the reason, a conclusion without the premises; but brickmakers were not always syllogistic in their style of putting an argument. The "dry-clayists" said that clay could be pressed dry, so as to make it sufficiently compact for a brick. They

did not say precisely what condition the clay should be in, nor just what the maximum of pressure should be. They contented themselves with a mass of clay in the shape of brick, without any reference to the law of cohesive attraction, so that it was for a long time before anything like a good brick was made by the dry-press machines. There are two forces only which can be used in making a given quantity of clay into brick. One is by natural crystallization. The other is by pressure; or, in other words, more technical, artificial cohesive attraction. The more clay is dissolved and stirred or tempered the better the crystallization. The more it is pulverized, comminuted and stirred together for dry pressure, and the more it is pressed, until all the particles are completely united, the more perfect is the cohesive attraction. There is a maximum or necessary pressure for every kind of clay, under certain conditions. If clay has an excess of sand in it, it requires more pressure. If it be well pulverized and damp, it takes less pressure than if dry and partially pulverized, but, in any case, the pressure must reach that point where the particles are all perfectly united, and are no longer compressible.

We hear talk of the great power of machines to press clay into brick—some say 40 tons to a brick, some 100, etc. This is all speculative. It may, in some cases, take only 25 tons, and might reach 100 in other cases.

SANDY CLAY IN A DRY STATE, IS NON-ELASTIC.

If, after all the particles are perfectly cohered under, say, a pressure of 40 tons, an addition of 1,000 tons would

not reduce the size of the brick, so that the great surplus power of a brick machine avails nothing after the maximum pressure required has been given. This is why I have thought the roller principle of pressure was preferable to the direct, the cam or toggle-joint.

If a toggle-joint machine has nothing to relieve the strain after the brick has received the maximum "pressure," it will work well, provided some plan be devised by which the brick can be cut off to a uniform thickness.

It is a very difficult task to charge the molds or dies every time they act with just the same quantity of clay, and if there be a variation of two or three ounces the machine is over-strained or the clay is not perfectly cohered. This cannot be said of a machine where the clay is pressed into a mold by a roller, which, of course, must be of the right size to gather a full supply of clay into the molds as it impinges upon the clay, and if an excess of clay is in contact with the roller and the surface of the molds, the roller will move it forward into the next mold. If those who use toggle-joint, or other plunger, or what I call direct-pressure machines, have an automatic device for getting precisely the right quantity of clay in every die, there can be no serious objection to them.

THE PROGRESS OF LABOR SAVING DEVICES IN BRICK-MAKING.

It is not that machinery can do a much greater percentage of work than the old hand methods which makes it desirable, but it is that manual labor is much relieved of its excessive toil, and the condition of the em-

ployes ameliorated in all cases where the relations of the employer and employe are conducted on the principles of justice and equity.

Sixty years ago, I have seen in the city of Cincinnati 9,000 brick made as a regular day's work, by one molder. One man to put mud on his table, one man to carry off molds and dump the brick on the yard, one man to dig and haul clay in the pits, one man to wheel dry brick off the yard and put them under the shed ready to set, and one boy to drive the oxen that tempered the clay, in round pits, that held about 3,000 brick, making in all five men and one boy to the task of 9,000 brick. The molds had six brick, three lengthwise side by side. The molder would handle his mold from sand box to table, and cutting down his walk with both hands in the shape of an oyster, would throw it into the molds at the rate of one every second, and then strike off the clay from the top of the molds in about three seconds, making six brick every ten seconds. I well remember a celebrated race by two stalwart, expert molders in 1832. They were to mold from sunrise to sunset. Bets ran high, and all the brickmakers in Cincinnati stopped work that day to witness the contest. When the time for molding was up, at sunset, one of the molders had molded 25,000 brick, the other 24,700. This may seem incredible, but I was an eye witness to this prodigious feat of skilled labor. The names of the contestants were Martin and Conell. Martin won the bet.

There is no machine that can turn out an average work to exceed 1,500 brick to each hand em-

ployed, so that the gain by machinery is to be found in the improved conditions of the labor experts, in the uniform superior quality of the brick, in the appliances for saving time, by working through all seasons of the year, and most of all, in the tendency to produce a general community of mutual interest among brickmakers, and, by intelligent co-operation, develop every advantage and improvement of which the art is susceptible.

THE PROBLEM OF CHEAP BURNING AND GOOD BURN-
ING AND OF STANDARD BRICK IN SIZE
AND QUALITY.

Hitherto, the progress in the mere manufacture of raw, unburned brick has outrun improvements in the quality, and in the methods of burning. The majority of inventors of brick machinery have not been experts in brick burning. They conceive of some way to press clay into a mold and get out a brick, but they do not first stop to consider the nature and quality of the clay, or the necessary treatment of it in the final and most important stage of manufacture—the burning. The usefulness and character of brick machines, especially of the dry press kind (the brick of which requires thoroughly hard burning and slow cooling) have been less appreciated for the want of proper skill in setting and burning the brick made by them, than from any other cause. First, to have good brick the clay must be good and the maker and burner know the properties of it in relation to fire and induration. Knowing these things, he must set and burn accordingly.

SETTING BRICK IN A KILN FOR BURNING.

There is generally a fault in setting the benches and overhangers of kilns. It is common to set one brick over and on the space between two, thereby closing up the space intended for the draft from combustion of the fuel. This not only retards combustion, but it prevents a sufficient heat from ascending through the body of the kiln. The benches, overhangers and binders should be set so that the flame and smoke will readily escape from the arches or furnaces up into the kiln. The habit of putting on platting tight or close, so as to keep the heat in the kiln, is not only without reason, but it is a positive damage to the brick and to the proprietor. It is about as sensible as to put a damper over a chimney of a house to keep the heat in.

There is an infallible rule for a good draft from the combustion of the fuel, viz.: The space for the entrance of cold air into the furnace must not be more than one-third that of the flues of the smoke stack. For instance, if the doors of the arch or furnace to a kiln of brick have an area of two feet or 144 inches each, the space between the brick in the arch should give a clear outlet for smoke and gas of at least six square feet or 864 inches clear of obstruction. The top of the kiln should never be less open than the kiln throughout, only when the kiln begins to settle, and a kiln should never be brought to a settling heat in the arches until the fires are all out at top with a heat nearly the same as in the arches, then the heat may be increased in the arches, and as soon as any

part of the kiln begins to settle that part should be closed tight either with platting or damp loam or fine clay. I prefer to use bats for platting and clay to make the platting tight. As the settling appears, the covering should progress until the entire top surface of the kiln be covered with a thin coat of clay. This treatment is explained at length in the sixth chapter of this book. Some so-called brickmakers say that clay should not be put on a kiln, and that the platting can be closed sufficiently tight. If platting is to be closed tight it must be put on with good whole brick, and then when they are drawn together, a hot, difficult job is on hand, and as spaces are left they must be filled with brick, which is not easy or quick done, and when done is not as good as when done with clay.

The clay covering is burned, and when thrown off with the bats it does not go down into the kiln, and if the bats and clay be thrown into a pile together they can be used to make what fire brickmakers call "grog."

UTILIZING THE EXHAUSTING HEAT TO DRY OFF GREEN KILN.

There is no serious trouble in utilizing the heat, coming from a kiln just burned, to partially dry off a "green" kiln. Much thought and attention has lately been given to this subject, and as fuel becomes more scarce, the idea for using waste heat will progress until the continuous kiln will be a complete thing, and be a valuable and necessary factor in producing a good, uniform brick.

A UNIFORM SIZE AND WELL BURNED BRICK WITH A
NOMENCLATURE FOR KIND AND CLASSES A
NATIONAL WANT.

One of the great drawbacks and injuries to good, skillful brickmakers is the fact: First, that few people know the difference between a first rate and second or third rate brick. A brick may be only half burned and look well on the outside. Second, there is no uniform size for brick. This makes it difficult for two different manufacturers of brick to supply the same job or building with brick, and also tends to disturb and unsettle prices for brick. Some foolish brickmakers will increase the size of their brick, thinking to get a higher price for their brick, while they deceive themselves with the idea that it costs no more to make a brick $2\frac{1}{2}$ inches thick than if it were $2\frac{1}{4}$ inches thick. Third, a committee should be appointed representing all sections of the Union which should define and classify brick under significant proper names; also fix a uniform size for brick and one that would insure the best brick and make it easy to make, set, burn and handle. And I will say here in advance, that the best size for a brick for all concerned is $8\frac{1}{2}$ inches long, $4\frac{1}{4}$ inches wide and $2\frac{1}{4}$ inches thick. This size (burned, of course) gives a little over 78 cubic inches. All brickmakers would have to make their molds or dies to suit their clay. A thin brick will carry more weight than a thick one, they are dried quicker and burned easier and better. A man can take two brick in one hand if they are not over $2\frac{1}{4}$ inches thick, and if any change should be made in the size here proposed the thickness

should be reduced to $2\frac{1}{2}$ inches, which, in my judgment, is the true and best standard thickness for the best and most profitable brick.

AS TO A NOMENCLATURE FOR BRICK.

The common names "red brick," "pale red brick," "dark salmon," "light salmon" are all at fault. Not half of the clay of which brick are made will burn a red color. What a Philadelphia brickmaker would call a red brick, a brickmaker here in many parts of the south would call a salmon brick, as most of our red brick, though as hard as a Philadelphia red brick, are really salmon brick.

I would suggest the simple designation, in reference to hard brick, Hard Arch (H. A.); for next above the arches I would say No. 1 hard (called in Philadelphia, pavers); for next above, No. 2 hard; next above, No. 3 hard; and next, No. 4 salmon; all abbreviated would be (H. A.) (No. 1 H.) (No. 2 H.) (No. 3 H.) and (S.) or salmon. Then for front brick I would say, best quality front, abbreviated, (B. Q. F.) then (2nd Q. F.) and (3rd Q. F.) all hard, of course, for no other kind of brick should be laid on the outside of a wall. The habit of using what are called "pale or light stretchers," is a very pernicious one, and no good builder will tolerate it. The truth is, the standard of brick burning is too low. It offers a premium to botch brickmakers, and the good, competent brickmaker must ever face an unworthy competitor or retreat ingloriously.

Our general practice of letting out building by con-

tract, all to one man, is not only fatal to good building, but is a downright injustice and leads to dishonesty. Let us look at it a moment. A wants building done; he puts it in the market for the lowest bidder; B is his architect and manager; he has written out a specification that would rival all the classics in learning, and "Blackstone" in technicalities. The verdant, well-meaning bidders will read over his profound stereotype literature and wonder at the possibility of evading or dodging its punctilious requirements, so he takes the trouble of making out an honest estimate and puts in his bid. The day when the bids are opened up comes Mr. C, more "nonchalant" than polite, but he is the right-hand man for B, and only gives a wink and a nod to see the "cat jump." He is awarded the job; though he has no practical experience with mechanics' tools, architectural proportions or requisites, he readily supplies these deficiencies with a glib tongue and a self-conceit and importance that only measures its chances for success by its opportunities. C now goes for the material man; he finds the half-and-half brickmaker; he is full of stock from No. 2 to No. 4, but deficient in No. 1, still they will do to haul to the building C has taken, to make a blind with. One good brick will hide two bad ones, where the supervising architect is "near sighted" or busy looking at the "oily" part of the fact. In short, C gets cheap brick and cheap everything else for his job. Now, if the proprietor A had sent an expert, well qualified to buy all his building material, then employed a first-rate mechanic, in each line required, to build and complete his

house, under the general supervision of a good and well-known practical building architect, all concerned and the general public would have the benefit of a legitimate, competent, progressive, skilled industry, in every line of building business.

BRICK WILL PREDOMINATE AS THE FUTURE BUILDING MATERIAL.

The whole business of brickmaking should be revised, and intelligently understood, as well as the proper and best way to use brick as a building material. All things considered in the economy of building, brick and terra cotta are incomparably the best, and the time is not distant when nothing but fire-proof brick buildings will be in demand, or even tolerated.

Gentlemen of the convention, it is no flattery to tell you that your position is really one of the most remarkable and merited distinction. It has no parallel in the history of the world. I have read of no useful art except brickmaking that has been nursed in the cradle of conservatism, 4,100 years, without some intelligent conventional effort to develop its importance and possibilities.

Allow me to congratulate you on being the pioneers in giving progressive shape and intelligent direction to brickmaking. Since the building of Babel you are the first body of men who have, in good earnest, said, "Let us make brick and burn them thoroughly." You have not only taken up the refrain of Noah's descendants, to burn them thoroughly, but you have caught the voice of

American genius, which plainly says; "Let us not only make brick and burn them thoroughly, but let us also make them thoroughly," not to build towns that will "confuse our language" or show our want of honest skill or wisdom, but to build houses and homes that will diffuse our comforts, increase our enjoyments, honor our intelligence and wisdom, and show to the world that our brick is like our country and government, the best on earth. [Applause.]

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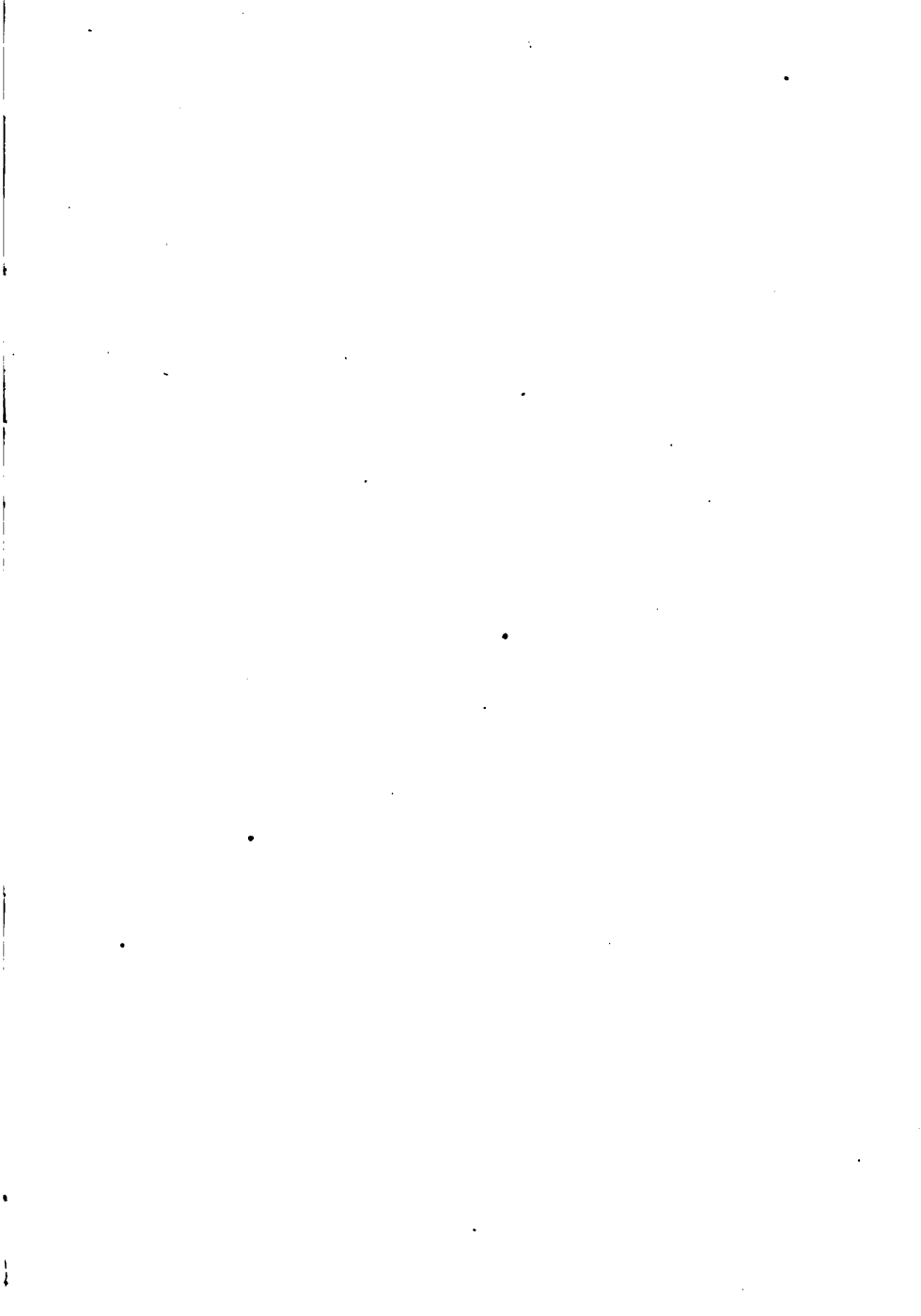
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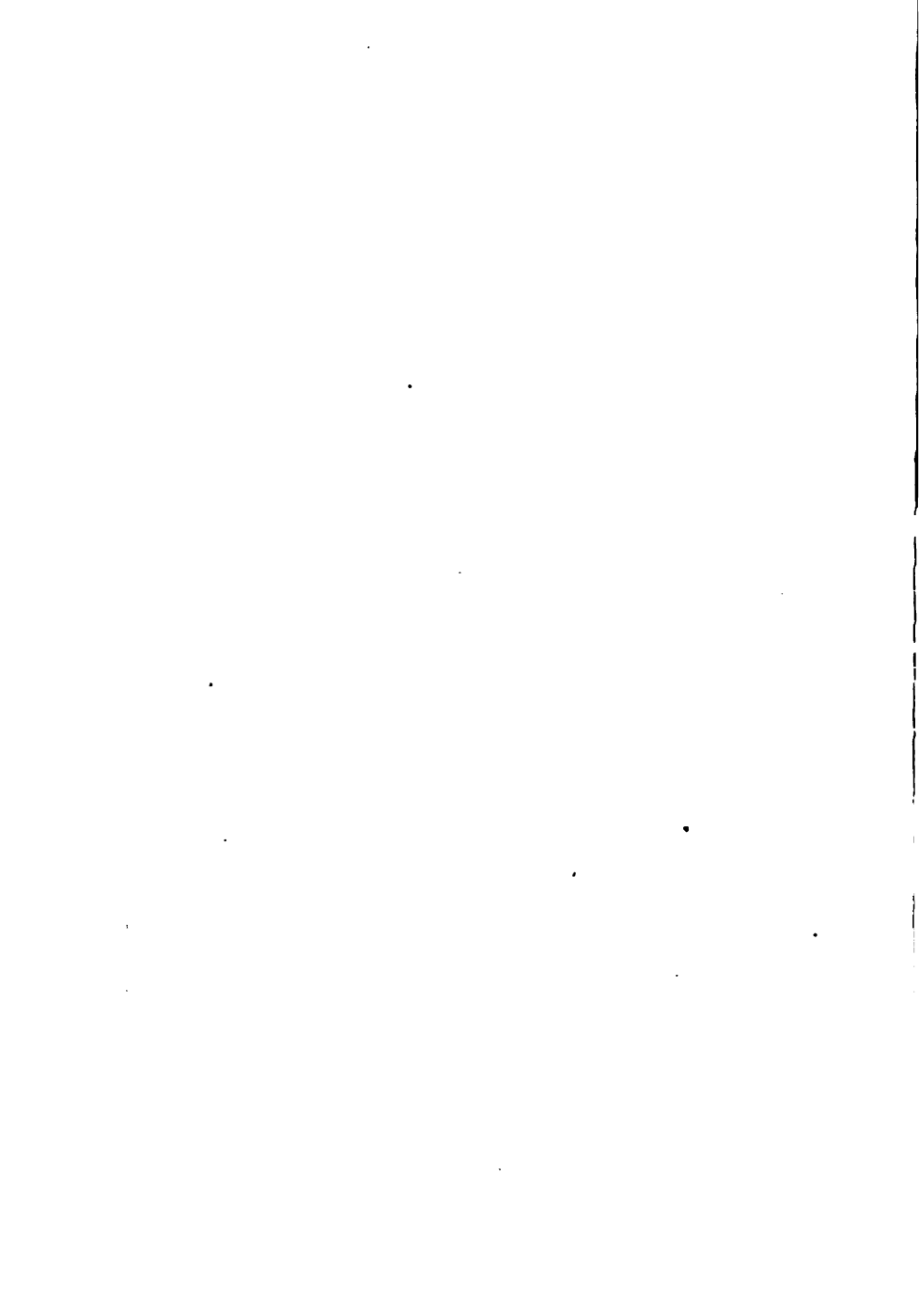
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